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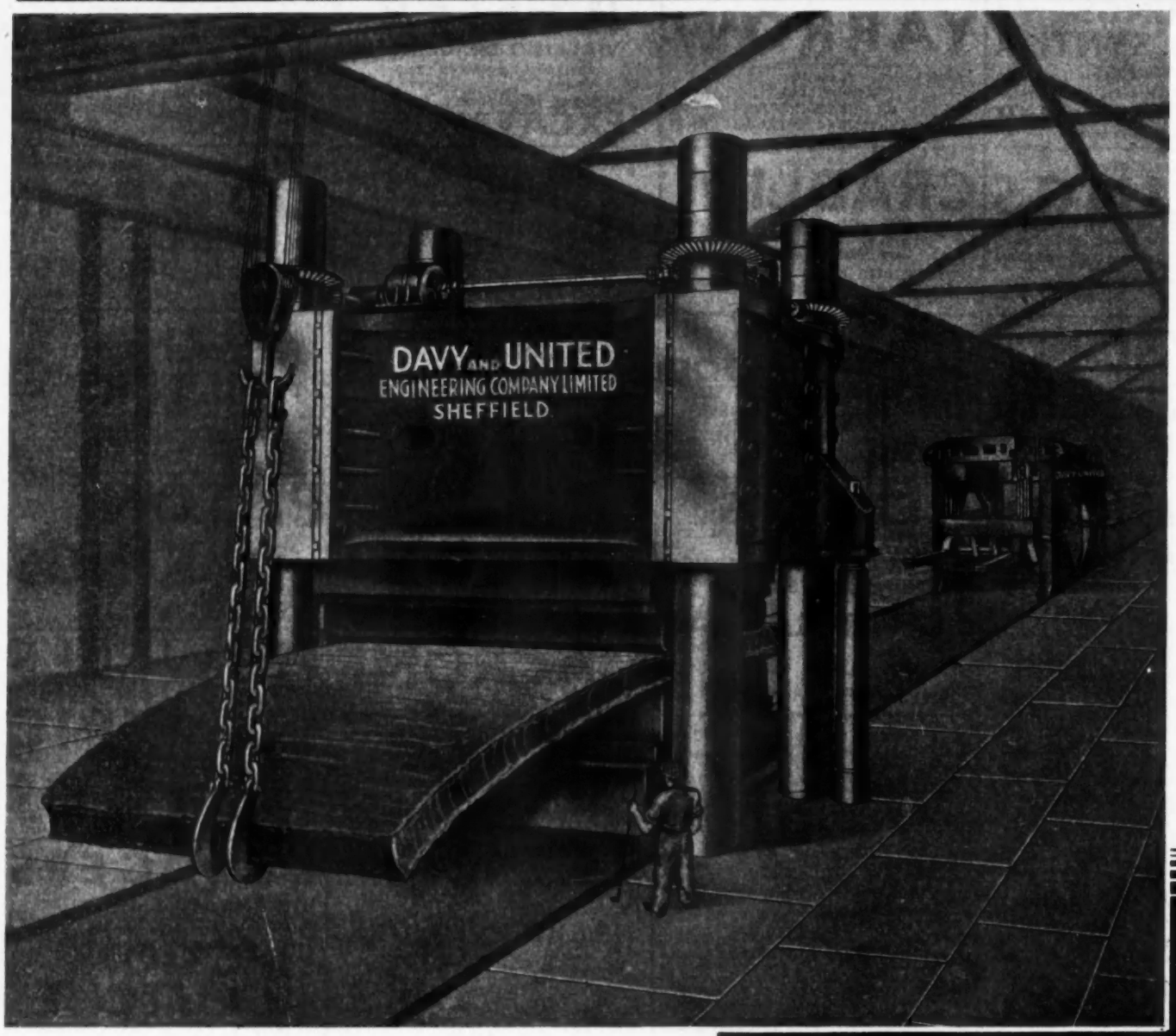

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NON-AXIAL LOADS ON STRUCTURAL STEELWORK BEAMS.

By R. F. DAVIS, M.Sc., A.M.I.Mech.E.

NON-AXIALLY loaded beams occur frequently in boiler-supporting structures and furnace work, where, in order not to expose the steelwork to high temperatures, the refractory and insulating materials are necessarily non-axially supported; other instances of non-axial loading, of course, arise in other classes of structural steelwork. The calculation of the fibre stresses in such beams presents difficulty owing to the flexure of the components of the beam by twisting. The twisting couple produces torsion in the webs and flanges due to each component being twisted about its own axis; at the same time the top and bottom flanges are deflected to either side of the beam axis causing, in addition, lateral bending stresses in the flanges. If the member has a double web section there may also be appreciable vertical bending of the two halves of the section upwards and downwards, respectively.

One empirical method of calculation is to assume that the whole of the twisting couple is restrained by the horizontal flexure of the flanges, the torsional restraint of the beam being neglected. Another method is to assume that the horizontal flexure of the flanges takes a fixed proportion of the twisting couple. The method presented here is an extension of that proposed by Timoshenko* for the particular case of a central torque on a simple I beam, to other types of loading and structural members.

A beam having a non-axial load W, Fig. 1, applied at an eccentricity e with the flexural axis of the beam can be replaced by superposition by an axial load W and a couple W e, Fig. 2. The bending stress and vertical deflection of the beam due to the axial load W can be found in the usual manner, but the couple W e is partly restrained by shear torsion and partly by flexure of the flanges. It can be assumed that where the ends of the beam have riveted connections they are in accordance with the usual design procedure for this type of joint, freely held; that is the ends of the beam cannot rotate about a longitudinal axis, but are, nevertheless, free to warp. The expression "ends free" is used throughout with the foregoing meaning. Where the ends of the beam are rigidly built into and gripped by concrete, or adequately welded to another member, so as to prevent warping of the ends, the ends are denoted as "fixed."

Uniformly Distributed Non-Axial Load (Ends Free).—In the case of a uniformly distributed load, by symmetry the torque at each end is $T = \frac{1}{2} W e$, also the cross section at the mid-span remains plane and may be considered as "fixed" with respect to either end. Consider, therefore, one half only of the beam of total span $2l$, as in Fig. 3. The torque per unit length is $\frac{W e}{2 l}$ and the torque at any section x from the "fixed end" is therefore

$$T_x = \frac{W e x}{2 l} \quad . \quad . \quad . \quad . \quad (1)$$

Let ϕ be the angle of twist for any cross section of the beam, Fig. 4; then $\frac{d\phi}{dx} = \theta$ is the angle of twist per unit length of the beam. That part of the torque which is balanced by the torsional shearing stresses due to twist is

$$T' = C \theta \quad . \quad . \quad . \quad (2)$$

in which C is the torsional rigidity of the bar.

In order to determine the portion T″ of the torque which is balanced by the shearing forces in the flanges due to bending, we must consider the bending of a flange, Fig. 4. Denoting by h the distance between the centroids of the flanges, the deflection at any cross section of the upper flange is

$$z = \frac{h \phi}{2} \quad . \quad . \quad . \quad (3)$$

and by differentiation

$$\frac{d^2 z}{dx^2} = \frac{h}{2} \cdot \frac{d^2 \phi}{dx^2} = \frac{h}{2} \cdot \frac{d^2 \theta}{dx^2}.$$

Denoting by D the flexural rigidity of one flange in the plane $x\,z$ and noting that z is positive upwards, the equation for the shearing force in the flange due to bending is

$$Q = \frac{dM}{dx} = D \frac{d^3 z}{dx^3} = \frac{D h}{2} \frac{d^2 \theta}{dx^2} \quad . \quad . \quad . \quad (4)$$

Considering the positive direction of Q, we therefore have

$$T'' = - Q h = - \frac{D h^2}{2} \frac{d^2 \theta}{dx^2} \quad . \quad . \quad . \quad (5)$$

and the total torque

$$T_x = T' + T'' \quad . \quad . \quad . \quad (6)$$

or

$$\frac{W e x}{2 l} = C \theta - \frac{D h^2}{2} \frac{d^2 \theta}{dx^2}.$$

Put

$$a^2 = \frac{D h^2}{2 C} \text{ and } K = \frac{W e}{2 C}$$

then

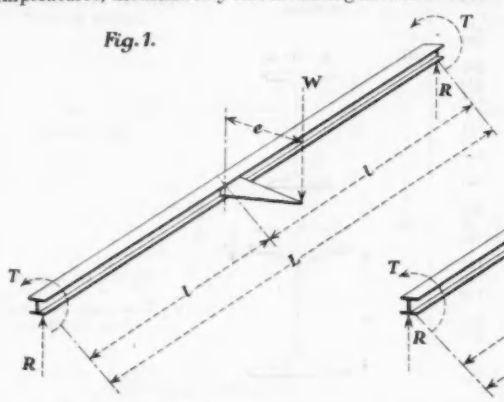
$$a^2 \frac{d^2 \theta}{dx^2} - \theta + \frac{k}{l} x = 0$$

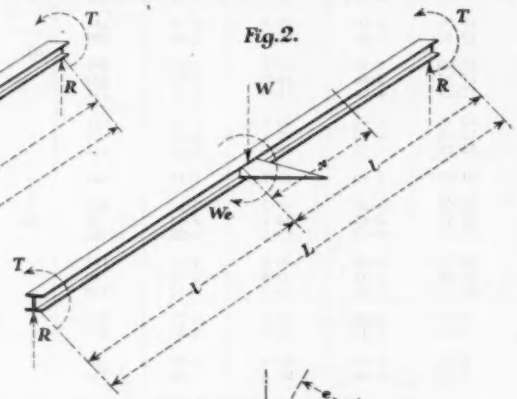
which is a differential equation of a well-known form having the general solution

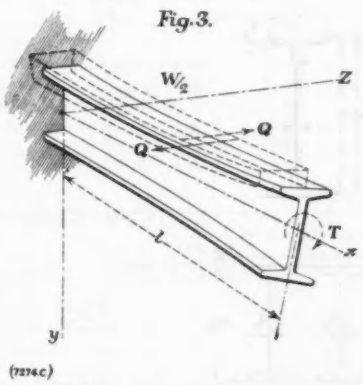
$$\theta = A e^{\frac{x}{a}} + B e^{-\frac{x}{a}} + \frac{k}{l} x.$$

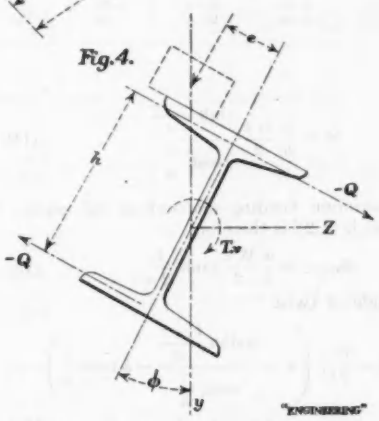
To determine the constants of integration A and B, we insert the limiting conditions; at the "fixed end" $x = 0$, then $\theta = 0$, and at the "free" end $x = l$, then $\frac{d\theta}{dx} = 0$, whence

$$\theta = \frac{W e}{2 C l} \left(x - \frac{a \sinh \frac{x}{a}}{\cosh \frac{l}{a}} \right) \quad . \quad . \quad . \quad (7)$$









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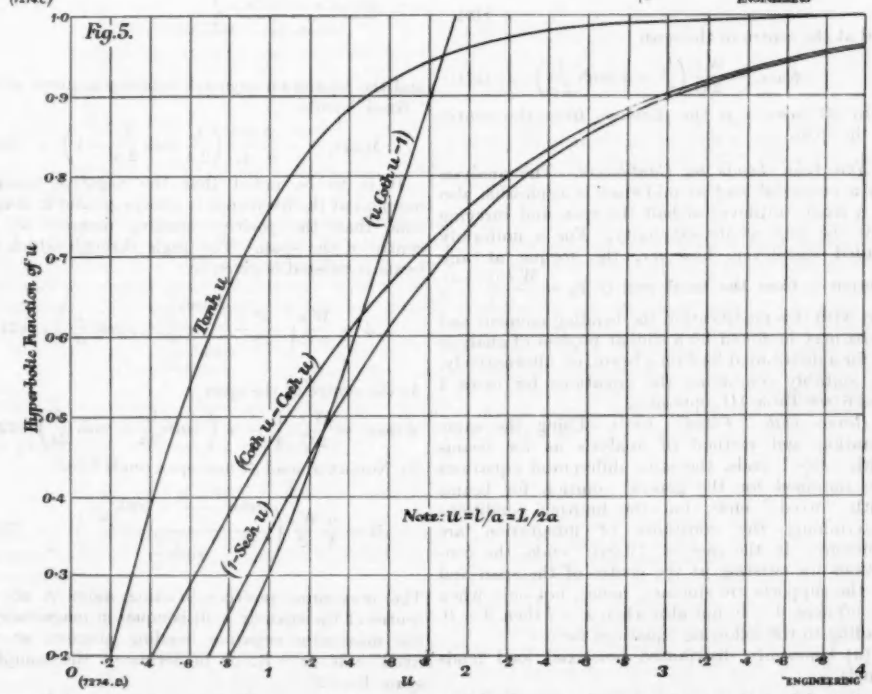


* Timoshenko, S., *Strength of Materials*, Part 1, pages 282 to 286.

NON-AXIAL LOADS ON STRUCTURAL-STEELWORK BEAMS.

TABLE I.—Dimensions and Properties of I Beams for Non-Axial Loads

Size, $d \times b$	Weight per Ft.	Moment of Inertia I_x (in.)^4.	Section Modulus, Z_x (in.)^3.	Moment of Inertia I_y (in.)^4.	h.	Form Factor. K_j (in.)^4.	Torsional Radius a.	$\frac{a}{h}$	$\frac{a^2}{h}$
In.	Lb.				In.		In.		
24 × 7½	95	2,533	211·1	62·54	22·99	5·09	62·8	2·73	171
22 × 7	75	1,677	152·4	41·07	21·17	2·94	61·6	2·91	179
20 × 7½	89	1,673	167·3	62·54	18·99	5·10	51·8	2·73	141
20 × 6½	65	1,226	122·6	32·56	19·18	2·29	56·4	2·94	166
18 × 8	80	1,292	143·6	69·43	17·05	3·99	55·5	3·25	181
18 × 7	75	1,151	127·9	46·56	17·07	3·66	47·3	2·77	130
18 × 6	55	842	93·5	23·64	17·24	1·64	51·0	2·96	151
16 × 8	75	974	121·7	68·30	15·06	3·63	50·8	3·37	171
16 × 6 H	62	725	90·6	27·14	15·15	2·70	37·4	2·47	93
16 × 6 L	50	618	77·3	22·47	15·27	1·45	46·8	3·06	143
15 × 6	45	492	65·6	19·87	14·35	1·19	45·7	3·19	145
14 × 8	70	706	100·8	66·67	13·08	3·32	45·7	3·50	160
14 × 6 H	57	533	76·2	27·94	13·13	2·43	34·7	2·64	92
14 × 6 L	46	443	63·2	21·45	13·30	1·23	43·2	3·25	140
12 × 8	65	488	81·3	65·18	11·10	3·02	40·3	3·63	147
12 × 6 H	54	356	62·6	28·28	11·20	2·41	29·9	2·67	80
12 × 6 L	44	317	52·8	22·12	11·28	1·35	35·7	3·17	139
10 × 8	55	289	57·7	54·74	9·22	2·35	34·7	3·76	131
10 × 6	40	205	41·0	21·76	9·29	1·13	31·8	3·42	109
9 × 7	50	208	46·3	40·17	8·18	2·19	27·3	3·34	80
8 × 6	35	115	22·4	19·54	7·35	0·92	26·4	3·59	95

Equation (4) gives the shearing force in the flanges, and from this the bending moment in each flange is

$$M = \frac{D}{2} h \frac{d\theta}{dx}$$

or, substituting from equation (7) for θ

$$M = \frac{a^2}{h} \frac{W e}{2 l} \left(1 - \frac{\cosh \frac{x}{a}}{\cosh \frac{l}{a}} \right) \quad . \quad (8)$$

The bending moment is a maximum at the "fixed end" (or centre of the complete span); hence, putting $x = 0$

$$M_{max.} = \frac{a^2}{2 h l} W e \left(1 - \operatorname{sech} \frac{l}{a} \right) \quad . \quad (9)$$

or in terms of the complete span $L = 2l$

$$M_{max.} = \frac{a^2}{h} \frac{W e}{L} \left(1 - \operatorname{sech} \frac{L}{2a} \right) \quad . \quad (10)$$

To obtain the angle of twist ϕ we use equation (7). Remembering that $\theta = \frac{d\phi}{dx}$, integrating equation (7) and adjusting the constant of integration to make $\phi = 0$ when $x = 0$, we obtain

$$\phi = \frac{W e}{2 C l} \left(\frac{x^2}{2} - \frac{a^2 \cosh \frac{x}{a}}{\cosh \frac{l}{a}} + a^2 \operatorname{sech} \frac{l}{a} \right) \quad . \quad (11)$$

Substituting $x = l = \frac{L}{2}$ in this equation, the angle of twist at the centre of the span is

$$\phi_{max.} = \frac{W e}{C} \left\{ \frac{L}{8} - \frac{a^2}{L} \left(1 - \operatorname{sech} \frac{L}{2a} \right) \right\} \quad . \quad (12)$$

It should be noted that in all cases x is the distance from the centre of the span.

Non-Axial Load at Mid-Span (Ends Free).—The considerations which apply to a non-axial evenly distributed load W apply also to a non-axial load W at mid-span, except that the torque at any section along each half of the beam is constant and is $T = \frac{W e}{2}$, so that using the same notation the differential equation for the torque at any section becomes

$$a \frac{d^2\theta}{dx^2} - \theta + k = 0,$$

whence

$$\theta = \frac{W e}{2 C} \left(1 - \frac{\cosh \frac{l - x}{a}}{\cosh \frac{l}{a}} \right) \quad . \quad (13)$$

and

$$M = \frac{a}{h} \frac{W e}{2} \frac{\sinh \frac{l - x}{a}}{\cosh \frac{l}{a}} \quad . \quad . \quad (14)$$

The maximum bending moment at the centre of the span $L = 2l$ is therefore

$$M_{max.} = \frac{a}{h} \frac{W e}{2} \tanh \frac{L}{2a} \quad . \quad . \quad (15)$$

The angle of twist

$$\phi = \frac{W e}{2 C} \left(x + \frac{a \sinh \frac{l - x}{a}}{\cosh \frac{l}{a}} - a \tanh \frac{l}{a} \right) \quad . \quad . \quad . \quad (16)$$

and at the centre of the span

$$\phi_{max.} = \frac{W e}{2 C} \left(\frac{L}{2} - a \tanh \frac{L}{2a} \right) \quad . \quad (17)$$

In all cases x is the distance from the centre of the span.

Non-Axial Loads on Cantilevers.—The analysis for a non-axial load at mid-span is applicable also to a fixed cantilever of half the span and carrying half the load at its extremity. For a uniformly loaded cantilever, however, the torque at any section x from the fixed end is $T_x = \frac{W e (l - x)}{l}$, but with this modification the bending moment and twist may be found by a similar process of analysis as for a distributed load on a beam, or, alternatively, by suitably combining the equations for cases 1 and 6 (see Table III, opposite).

Beams with "Fixed" Ends.—Using the same notation and method of analysis as for beams with "free" ends, the same differential equations are obtained for the general solution for beams with "fixed" ends, but the limiting conditions determining the constants of integration are different. In the case of "fixed" ends, the conditions for twisting at the centre of the span and at the supports are similar; hence, not only when $x = 0$ does $\theta = 0$, but also when $x = l$ then $\theta = 0$, leading to the following equations for :—

(*a*) Uniformly distributed non-axial load (ends fixed)

$$M = \frac{a^2}{h} \frac{W e}{2 l} \left(1 - \frac{l}{a} \frac{\cosh \frac{x}{a}}{\sinh \frac{l}{a}} \right) \quad . \quad . \quad (18)$$

or, in terms of the total span $L = 2l$, the maximum positive bending moment at the centre of the span is

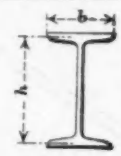
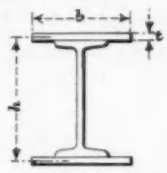
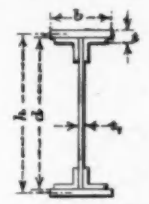
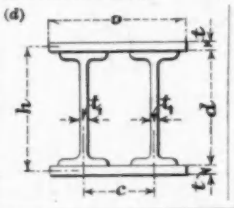
$$M_{max.} = \frac{a^2}{h} \frac{W e}{L} \left(1 - \frac{L}{2a} \operatorname{csch} \frac{L}{2a} \right) \quad (19)$$

TABLE II. *Torsional Form Factor.*

All dimensions in inches. For values of K_j see Table I.

Torsional Radius $a = 0{\cdot}78\, h \sqrt{\frac{I_y}{K}}$

h = Distance between centroids of flanges.

Section.	Approx. Torsional Form Factor K (in.)^4.
(*a*) 	K_j (See Table I).
(*b*) 	$K_j + \frac{2}{3} bt^3 - 0{\cdot}4t^4$ (K_j is the Form Factor of the Joist Section.)
(*c*) 	$\frac{2}{3} bt^3 + \frac{dt_1^3}{3} + 0{\cdot}3t_1t^3 - 0{\cdot}4t^4$
(*d*) 	$\frac{2c^2t_1d^2t}{ct_1 + dt}$

and the maximum negative bending moment at the "fixed" ends

$$M_{max.} = -\frac{a^2}{h} \frac{W e}{L} \left(\frac{L}{2a} \coth \frac{L}{2a} - 1 \right) \quad . \quad (20)$$

It is to be noted that the negative bending moment at the fixed ends is always greater in magnitude than the positive bending moment at the centre of the span. The angle through which the beam is twisted is given by

$$\phi = \frac{W e}{2 C} \left(\frac{x^2}{2l} - \frac{a \cosh \frac{x}{a}}{\sinh \frac{l}{a}} + a \operatorname{csch} \frac{l}{a} \right) \quad . \quad (21)$$

At the centre of the span

$$\phi_{max.} = \frac{W e}{2 C} \left\{ \frac{L}{4} - a \left(\coth \frac{L}{2a} + \operatorname{csch} \frac{L}{2a} \right) \right\} \quad (22)$$

(*b*) Non-axial load at mid-span (ends fixed)—

$$M = \frac{a}{h} \frac{W e}{2} \left(\frac{\cosh \frac{l - x}{a} - \cosh \frac{x}{a}}{\sinh \frac{l}{a}} \right) \quad . \quad (23)$$

The maximum positive bending moment at the centre of the span ($x = 0$) is equal in magnitude to the maximum negative bending moment at the fixed ends ($x = l$), or in terms of the complete span ($L = 2l$)

$$M_{max.} = \pm \frac{a}{h} \frac{W e}{2} \left(\coth \frac{L}{2a} - \operatorname{csch} \frac{L}{2a} \right) \quad (24)$$

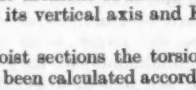
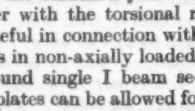
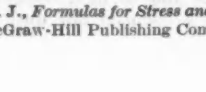
and the angle of twist

$$\phi = \frac{W e}{2C} \left(x - \frac{\cosh \frac{x}{a} - \cosh \frac{l - x}{a} + \cosh \frac{l}{a} - 1}{\frac{l}{a} \sinh \frac{l}{a}} \right) \quad (25)$$

NON-AXIAL LOADS ON STRUCTURAL STEELWORK BEAMS.

TABLE III.—BENDING STRESSES AND DEFLECTIONS.

W = Total load (tons). All dimensions in inches. Stresses in tons per square inch. Angle of twist in radians. Modulus of elasticity E and of rigidity G in tons per square inch. See Tables I and II for form factor K and rigidity factors a, a/h, a^2/h. Width of flanges = b. Eccentricity of load with flexural axis = e. For hyperbolic functions see Fig. 5. I_y = moment of inertia about vertical axis (in.^{4}). Section symmetrical about horizontal axis, modulus = Z_x (in.^{3}). Moment of inertia = I_x (in.^{4}).

Loading.	Maximum Bending Stress due to Vertical Load. f_v.	Maximum Bending Stress due to Twisting Couple. f_t.	Maximum Vertical Deflection. δ max.	Maximum Angle of Twist. ϕ max.
1. Ends Free. Uniform Load. 	$\frac{W L}{8 Z_x}$	$\frac{a^2}{h}\frac{W e b}{L I_y}\left(1-\operatorname{sech}\frac{L}{2a}\right)$	$\frac{5}{384}\frac{W L^3}{E I_x}$	$\frac{W e}{K G}\left\{\frac{L}{8}-\frac{a^2}{L}\left(1-\operatorname{sech}\frac{L}{2a}\right)\right\}$
2. Ends Free. Centre Load. 	$\frac{W L}{4 Z_x}$	$\frac{a}{h}\frac{W e b}{2 I_y}\tanh\frac{L}{2a}$	$\frac{W L^3}{48 E I_x}$	$\frac{W e}{2 K G}\left(\frac{L}{2}-a\tanh\frac{L}{2a}\right)$
3. Ends Fixed. Uniform Load. 	At Ends. $\frac{W L}{12 Z_x}$	At Ends. $\frac{a^2}{h}\frac{W e b}{L I_y}\left(\frac{L}{2a}\coth\frac{L}{2a}-1\right)$	$\frac{W L^3}{384 E I_x}$	$\frac{W e}{2KG}\left\{\frac{L}{4}-a\left(\coth\frac{L}{2a}+\operatorname{csch}\frac{L}{2a}\right)\right\}$
4. Ends Fixed. Centre Load.	At Centre and Ends. $\frac{W L}{8 Z_x}$	At Centre and Ends. $\frac{a}{h}\frac{W e b}{2 I_y}\left(\coth\frac{L}{2a}-\operatorname{csch}\frac{L}{2a}\right)$	$\frac{W L^3}{192 E I_x}$	$\frac{W e}{K G}\left\{\frac{L}{4}-a\left(\coth\frac{L}{2a}+\operatorname{csch}\frac{L}{2a}\right)\right\}$
5. Cantilever. Uniform Load.	$\frac{W l}{2 Z_x}$	$\frac{a^2}{h}\frac{W e b}{l I_y}\left\{\frac{l}{a}\tanh\frac{l}{a}-\left(1-\operatorname{sech}\frac{l}{a}\right)\right\}$	$\frac{W l^3}{8 E I_x}$	$\frac{W e}{K G}\left\{\frac{l}{2}+\frac{a^2}{l}\left(1-\operatorname{sech}\frac{l}{a}\right)-a\tanh\frac{l}{a}\right\}$
6. Cantilever. End Load.	$\frac{W l}{Z_x}$	$\frac{a}{h}\frac{W e b}{I_y}\tanh\frac{l}{a}$	$\frac{W l^3}{3 E I_x}$	$\frac{W e}{K G}\left(l-a\tanh\frac{l}{a}\right)$

$$\phi_{max.}=\frac{W e}{C}\left\{\frac{L}{4}-a\left(\coth\frac{L}{2a}+\operatorname{csch}\frac{L}{2a}\right)\right\} \quad (26)$$

In all cases x is the distance from the centre of the span.

The Torsional Radius "a" and the Torsional Form Factor "K."—The factor "a" in the foregoing formulæ is a linear quantity and will be referred to as the "torsional radius" because it is a function of the resistance of the member against twisting by flexure, since

$$a^2=\frac{D h^2}{2 C}=\frac{h^2}{2}\cdot\frac{I_y}{2}\cdot\frac{E}{G K}.$$

For mild structural steel, the ratio E/G = 2·33 to 2·50, so that a mean value of the torsional radius for a structural steel section is given by

$$a=0{\cdot}78\,h\sqrt{\frac{I_y}{K}} \quad . \quad . \quad (27)$$

where I_y is the moment of inertia of the complete section about its vertical axis and K is its torsional form factor.

For plain joist sections the torsional form factor ($K=K_j$) has been calculated according to a formula given by Roark* based on the membrane analogy. The values thus calculated are given in Table I, opposite, for the standard joist sections commonly used, together with the torsional radius "a" and other data useful in connection with the calculation of the stresses in non-axially loaded beams.

For compound single I beam sections the additional flange plates can be allowed for approximately by adding the form factor of the plates K_f to that of the joist K_j. The form factor for the whole section K is, therefore, approximately

$$K=K_j+2K_f \quad . \quad . \quad . \quad (28)$$

where

$$K_f=\frac{b t^3}{3}-\frac{t^4}{5}$$

b = the width of the additional flange plates, and
t = the thickness of the additional flange plates.

The value of K for a double-web beam section is considerably greater than that for a single-web beam section of the same weight and is a maximum for a square-shaped section. The projecting flanges do not, however, appreciably affect the value of K and for simplicity these and the joist or channel flanges, or flange angles, will be neglected. The approximate value of K for a double-web section is then

$$K=\frac{2 c^2 t_1 d^2 t}{c t_1+d t} \quad . \quad . \quad . \quad (29)$$

where

c = the centres of the webs.
d = the depth of the joists.
t_1 = the thickness of the webs.
t = the thickness of the additional flange plates.

The values of K obtained in the above manner for single- and double-web compound sections are conservative and therefore on the safe side.

Joist beams having a low I_y are not suitable for resisting an appreciable twisting couple and are not given in Table I. For the same reason, channel members are not to be recommended, although the formulæ for twisting are applicable to channel sections, providing the eccentricity is taken about the true flexural centre.* Wherever there is considerable eccentricity of load a double-web section should be used if possible, especially if it is important, as in carrying a high wall, that the amount of twist should be a minimum. It should be noted that a double-web section has additional rigidity against twisting by virtue of the flexure of the two halves of the cross-section upwards and downwards, respectively. If it is attempted to take this into account in the mathematical analysis, it leads to complication and has, therefore, been neglected. Thus the deduced formulæ in this instance give a result in excess of the actual bending stress and likewise of the actual amount of twisting.

The maximum bending stress f_t in the flanges due to twisting is in all cases given by

$$f_t=\frac{M_{max.}\,b}{I_y} \quad . \quad . \quad . \quad (30)$$

where b is the width of the flanges and I_y is the moment of inertia of the complete section about its vertical axis. The total extreme fibre stress in the flanges is found by combining f_v and f_t (see Table III, above).

APPENDIX.—EXAMPLES.

1. (*a*) Find a suitable section for a beam having cleated connections at its supports 10 ft. apart and supporting a load of 4½ tons from a rigid bracket at mid-span and at an eccentricity of 9 in. from the beam axis. The extreme fibre stress is not to exceed 10 tons per square inch.

(*b*) Find also the angle of twist at the bracket and the vertical deflection at the point of application of the load.

(*a*) (Table III, Case 2) W = 4·5 tons, L = 120 in., e = 9 in. Since there is considerable eccentricity, it is desirable to use a beam with a high I_y. Try

* Roark, R. J., *Formulas for Stress and Strain*, Table 9, page 157. McGraw-Hill Publishing Company, 1938.

* See Roark, R. J., *Formulas for Stress and Strain*, Table 5, page 118. McGraw-Hill Publishing Company, 1938.

a 12 in. × 8 in. × 65 lb. R.S.J. (Table I) $Z_x = 81{\cdot}3$ in.^{3}, $I_y = 65{\cdot}18$ in.^{4}, $a = 40{\cdot}3$ in., $\frac{a}{k} = 3{\cdot}63$, $\frac{L}{2a} = \frac{120}{2} \times 40{\cdot}3 = 1{\cdot}49$. From Fig. 5, page 81, tanh $1{\cdot}49 = 0{\cdot}90$.

$$f_c = \frac{4{\cdot}5 \times 120}{4 \times 81{\cdot}3} = 1{\cdot}66 \text{ tons per square inch.}$$

$$f_t = \frac{3{\cdot}63 \times 4{\cdot}5 \times 9 \times 8 \times 0{\cdot}90}{2 \times 65{\cdot}18} = 8{\cdot}12 \text{ tons per square inch.}$$

Maximum combined bending stress 9·78 tons per square inch.

(*b*) Assume G = 5,400 tons per square inch. E = 13,000 tons per square inch. From Table II, page 82, K = K_j (Table I) $K_j = 3{\cdot}02$ in.^{4}, $I_x = 487{\cdot}8$ in.^{4}

$$\phi_{max.} = \frac{4{\cdot}5 \times 9}{2 \times 3{\cdot}02 \times 5400}\left(\frac{120}{2} - 40{\cdot}3 \times 0{\cdot}90\right) = 0{\cdot}296 \text{ radian} = 17 \text{ deg. nearly.}$$

$$\delta_{max.} = \frac{4{\cdot}5 \times 120^3}{48 \times 13{,}000 \times 487{\cdot}8} = 0{\cdot}026 \text{ in.}$$

Assuming the self-deflection of the bracket is negligible, the total deflection at the load

$$= \delta_{max.} + e \sin \phi_{max.}$$
$$= 0{\cdot}026 + 9 \times 0{\cdot}292 = 2{\cdot}654 \text{ in.}$$

NOTE.—If the amount of twist and deflection are undesirable, it would be advisable to use a double-web section.

2. A steel shaft 4 ft. long is rigidly welded at one end to a fixed thick plate, while a torque of 12·5 tons-in. is applied at the free end. Determine a suitable R.S.J. section, if the maximum fibre stress is not to exceed 7 tons per square inch.

In this case there is no axial load and the cantilever twists under a pure couple W $e = 12{\cdot}5$ tons-in., $l = 48$ in.

(Table III, Case 6) $f_v = 0$. ∴ a high I_y is required. Try 9 in. × 7 in. × 50 lb. R.S.J.

(Table I) $I_y = 40{\cdot}17$ in.^{4}, $a = 27{\cdot}3$ in., $\frac{a}{k} = 3{\cdot}34$.

$$\frac{l}{a} = \frac{48}{27{\cdot}3} = 1{\cdot}75. \text{ From Fig. 5 tanh } 1{\cdot}75 = 0{\cdot}94.$$

$$f_t = \frac{3{\cdot}34 \times 12{\cdot}5 \times 7 \times 0{\cdot}94}{40{\cdot}17} = 6{\cdot}85 \text{ tons per square inch.}$$

3. A compound beam section consisting of two 12-in. × 6-in. × 44-lb. R.S.J's at 7-in. centres, with 14-in. × ½-in. flange plates carries a wall load of 40 tons uniformly distributed over a span of 20 ft. at an eccentricity of 3 in. with the beam axis. What is (*a*) the maximum bending stress, and (*b*) the maximum twist of the beam, if the ends are rigidly welded to substantial stanchions ?

(Table III, Case 3) W = 40 tons, L = 240 in., $e = 3$ in.

From British Steelwork Association tables, $Z_x = 160{\cdot}7$ in.^{3}

$$f_c = \frac{40 \times 240}{12 \times 160{\cdot}7} = 4{\cdot}98 \text{ tons per square inch.}$$

(Table II, Case *d*)

$$K = \frac{2 \times 7^3 \times 0{\cdot}4 \times 12^2 \times 0{\cdot}5}{7 \times 0{\cdot}4 + 12 \times 0{\cdot}5} = 321 \text{ in.}^4$$

From B.S.A. tables, $I_y = 591{\cdot}5$ in.^{4}, assume $h = 11{\cdot}9$ in.

$$a = 0{\cdot}78 \times 11{\cdot}9\sqrt{\frac{591{\cdot}5}{321}} = 12{\cdot}6 \text{ in.}$$

$$\frac{L}{2a} = \frac{240}{2 \times 12{\cdot}6} = 9{\cdot}52.$$

This is outside the range of Fig. 5, and since in this particular case the hyperbolic factor does not approach unity with increase in the ratio $\frac{L}{2a}$ we have from tables

$$(9{\cdot}52 \coth 9{\cdot}52 - 1) = 8{\cdot}52$$

hence

$$f_t = \frac{12{\cdot}6^2 \times 40 \times 3 \times 14 \times 8{\cdot}52}{11{\cdot}9 \times 240 \times 591{\cdot}5} = 1{\cdot}35 \text{ tons per square in.}$$

Maximum combined bending stress at the fixed ends = 6·33 tons per square inch.

(*b*) Assume

G = 5,400 tons per square inch.

$$\phi_{max.} = \frac{40 \times 3}{2 \times 321 \times 5{,}400}\left\{\frac{240}{4} - 12{\cdot}6\ (1 + 0)\right\}$$
$$= 0{\cdot}00164 \text{ radian}$$
$$= 0{\cdot}1 \text{ deg. nearly.}$$

RECENT COURT CASES.—VIII.

By W. SUMMERFIELD, M.A., B.C.L., LL.B.

Emergency Street Lighting.—The courts have been increasingly occupied with claims for damages in respect of traffic accidents occurring during black-out periods. Two of the most important of these cases merit analysis, namely, *Wodehouse* v. *Levy and Another* (*St. Marylebone Borough Council, Third Party*), and *Greenwood* v. *Central Service Company, Limited* (*St. Marylebone Borough Council, Third Party*), since they involved consideration of the duties of local authorities and how far they are expected to go in the provision of safety devices for the benefit of traffic users while, at the same time, complying with Government requirements. The problems become the more difficult when apparently contradictory statutory provisions are simultaneously on the statute book, that is to say, where peace-time provisions have not been explicitly repealed by emergency measures.

In the first-mentioned case, the plaintiff, Wodehouse, claimed 275*l.* damages for personal injuries sustained when he was thrown against the glass partition of the taxicab in which he was travelling home along the Finchley-road, at midnight, on September 1-2, 1939, which was the first black-out night of the war ; he was so thrown by reason of the taxicab coming into violent collision with an unilluminated bollard at the end of a refuge in the middle of the road. He alleged against the first and second defendants, the owner and driver, respectively, of the taxicab, that they had been negligent in that the vehicle was being driven too fast in the circumstances. The defendants sought to place the responsibility upon the borough council, alleging that they had been negligent or guilty of breach of their duty in that they had failed to indicate the existence of an obstruction in the road, namely, the refuge, by illumination or other means. The Borough Council urged, in defence, that they had placed on the refuge such illumination as they were empowered by law to use, and that if, at the time of the accident, there was no illumination, the lights had gone out through no fault of theirs or had been removed by some other party. The Borough Engineer's office, it was said, estimated that the Council had lost, in two nights, 100 hurricane lamps out of 1,000.

Mr. Justice Cassels found for the plaintiff, for the sum claimed, with costs against all the defendants, and directed that three-quarters of the total so awarded should be paid by the Borough Council and one-quarter by the first and second defendants. In the course of his judgment, the Judge reviewed the development of the lighting restriction system in force. The evidence of the Deputy Borough Engineer showed that the refuge had been constructed, some four years prior to this accident, because of accidents occurring at that place to pedestrians. At each end there were solid guard-posts, and in the centre there was a high double-bracketed lamp standard. After the refuge had been provided, accidents occurred to vehicles which came into collision with it, and the Council, accordingly, placed illuminated bollards there, in addition to the solid guard-posts. These illuminated bollards had been in use for some considerable period prior to the war.

That some form of illumination for road obstructions would be necessary was always foreseen, as appears from the Memorandum which was circulated to local authorities by the Home Office (Air-Raid Precautions Department) and dated February 14, 1938. Further, in a memorandum dated June 1, 1939, the Home Office dealt with traffic signals, warning signs and illumination for obstructions, stating, *inter alia* : 'Obstructions on the carriageway of all roads . . . must be indicated by lights to drivers at night. Dimmed and well-screened hurricane lamps which throw no light above the horizontal and cast no appreciable glow on the road surface should be used for this purpose," and that "the candlepower of all lamps used for marking obstructions must be reduced to a figure not exceeding one." The memorandum included a recommendation to local authorities to provide themselves with screens for masking hurricane lamps and with a supply of screened and dimmed lamps for marking obstructions. The defendant borough council, even prior to September, 1938, had acquired a large number of hurricane lamps but, owing to the widespread demand for material among local authorities had not been able to acquire sufficient screening for all their illuminated bollards by the date of the outbreak of the war.

The effect in law of such a memorandum, it is to be noted, was not to impose obligations upon local authorities but to provide them with an indication of the sort of precautionary measures which were likely to be imposed. Statutory obligations were enacted by the Lighting (Restrictions) Order, 1939 (S.R. & O., 1939, No. 1098) which came into operation on September 1, 1939. Paragraphs 1 and 4 were particularly relevant to the issues in this case. They provide as follows : para. 1.—During the hours of darkness no light may be displayed ; and para. 4.—Para. 1 is not to apply in cases specified, among which are : (*c*) A light in the head of any illuminated bollard on an island refuge ; and (*d*) lamps indicating obstructions upon or near the carriageway of any road, provided that they are of candlepower not exceeding one and so screened as to prevent light being thrown upwards and any appreciable glow being produced on the road surface. The Order, it will be observed, followed closely on the lines of the memorandum of June, 1939.

The street refuge had been provided by the Council pursuant to powers conferred by Section 108 of the Metropolis Management Act, 1855 ; similar powers are vested in a variety of local authorities outside the Metropolis. Those statutory powers authorise "every vesting and district board from time to time to place any posts, fences and rails on the sides of any footways or carriageways in their parish or district, for the purposes of safety," and "to place any posts or other erections in any carriageway so as to make the crossings thereof less dangerous for foot passengers," and "from time to time to repair and renew any such posts, rails or fences, or to remove the same, or any other obstruction or encroachment on any carriageway or footway."

Section 130 of the Metropolis Management Act, 1855, lays down duties imposed upon "every vesting and district board." They "shall cause the several streets within their parish or district to be well and sufficiently lighted," and for that purpose "shall maintain, or set up and maintain, a sufficient number of lamps in every such street," and "shall cause the same to be lighted with gas or otherwise," and "to continue lighted at and during such times" as they may think "fit, necessary or proper" ; and "all public lamps, and the lamp posts and lamp irons and fittings thereof," to be provided by them are to remain vested in them. It was contended for the Council that these duties were repealed by the Order of 1939.

The Order, concluded the Judge, certainly modified the statutory duty to "cause the several streets to be well and sufficiently lighted," but the duty to light such obstructions as street refuges remained. While the Order is in operation, so that streets are unilluminated, they must ensure that obstructions are indicated at night by such lamps as satisfy the standard laid down in para. 4 (*d*) of the Order ; or, if an illuminated bollard is used, in accordance with the standard specified in para. 4 (*c*) of that Order. Nor was it open to the Council to say that what was alleged against them was mere non-feasance ; such a defence normally has reference to non-repair of a highway, alleged against a highway authority. Two statutory duties were imposed upon the Council, namely, to light the streets and to light obstructions. The latter was also a common law duty ; failure to

discharge such a duty is one thing, and failure to exercise a discretionary power is quite another; or, as it was put in *Kent and Porter* v. *East Suffolk Rivers Catchment Board* (1939), "a public authority which is empowered to do a thing, but not ordered to do it, may with impunity abstain from doing anything."

In *Greenwood* v. *Central Service Company, Limited (St. Marylebone Borough Council, Third Party)*, however, the Court of Appeal said that the Lighting Order of 1939 did repeal, temporarily, the provisions of Section 130 of the Act of 1855; that is to say, the Council's duty to members of the public no longer existed during the currency of the Order, so far as statute law was concerned. The common law duty, however, remained; anybody who had erected an obstruction in the highways must take care to avoid its becoming a danger. Failure to take care is negligence, and negligence involves legal liability to compensate anybody else who suffers in consequence of it. But failure to take care means failure to take reasonable care; and what is reasonable care must be interpreted in the light of the facts of each particular case; in this instance, in the view of the Court, the Council had taken reasonable care.

The facts of the case were as follows:—The plaintiff, Miss Greenwood, claimed damages in respect of personal injuries sustained by her when a taxicab in which she was being driven along Goodge-street, in the area of the St. Marylebone Borough Council, collided with an unlighted bollard of a refuge in the middle of the road. Negligence was alleged against the defendants, the Central Service Company, Limited, in that the taxicab was being driven too fast in the circumstances. The Central Service Company, against whom judgment was given, in the County Court, in the sum of 80*l*., with costs, sought to make the St. Marylebone Borough Council jointly liable on the ground that the unlighted bollard was the cause of the accident, which occurred at about 8 p.m., on October 7, 1939. The County Court (Deputy) Judge ruled against them, and against that decision the Central Service Company appealed.

It appeared from the evidence that the refuge in Goodge-street was normally sufficiently indicated by the ordinary street lighting arrangements of the Council, pursuant to the provisions of Section 130 of the 1855 Act. Those arrangements were abandoned when the Lighting Order of 1939 took effect; one candle-power hurricane lamps were, however, hung on all their refuge bollards, and, to ensure that they were kept properly lighted, men were employed, with the special instruction to go round the area regularly to inspect and attend to them. The lamp on the bollard at this refuge happened to be out at the time of the accident.

The Court of Appeal took the view that there was not an absolute duty imposed on the Council under the Act of 1855, in the circumstances, because the relevant provisions in that Act were abrogated by those in the Order; and, as to their common-law duty, they had taken reasonable steps to discharge it. The remedy of the injured plaintiff, accordingly, was against the Company, and the Company had no "remedy over," against the Council.

Other Emergency Lighting.—The Lighting (Restrictions) Order, 1939, which came into operation on September 1, 1939, was amended by the Lighting (Restrictions) (No. 2) Order, 1939, dated September 9, 1939, and was replaced, as from January 22, 1940, by the Lighting (Restrictions) Order, 1940 [S.R. & O. 1940. No. 74]. Regulation 24 of the Defence (General) Regulations, 1939 [S.R. & O. 1939. No. 927] also makes provision whereby the Minister for Home Security may promulgate Orders to control lights, by prohibiting or regulating their display, or with a view "to prevent or minimise the emission of flames, sparks or glare . . . so as to prevent useful information reaching the enemy. . . ." An Order was thus made by the Minister, under date April 17, 1940 [S.R. & O. 1940. No. 583], entitled the Lighting (Restrictions) (Amendment) Order, 1940. These Orders cover a wide range of activities in addition to street lighting and road traffic; for example, shops and places of public entertainment, railways, docks, waterways, aircraft and aerodromes.

INDUSTRIAL USES OF FLAMEPROOF ELECTRIC MOTORS

ELECTRIC motors, as produced by reputable manufacturers leave little to be desired on the grounds of reliability, low cost of maintenance and safety in operation. Numerous standard designs, which, generally speaking, are adaptable to a large variety of working conditions, are available. In mines and certain other situations, where the atmosphere may become charged with greater or less concentrations of explosive gases, special precautions in design and manufacture of the electrical equipment installed have, however, to be taken to reduce the risks arising from this cause. As the subject is of interest, both to the designer and the user, some discussion of it may be helpful, and the following article is based on notes supplied by Messrs. The British Thomson-Houston Company, Limited, Rugby, who have had wide experience in this field. The illustrations on this page, and on pages 86 and 90, are typical of the applications of the flameproof motors manufactured by this firm.

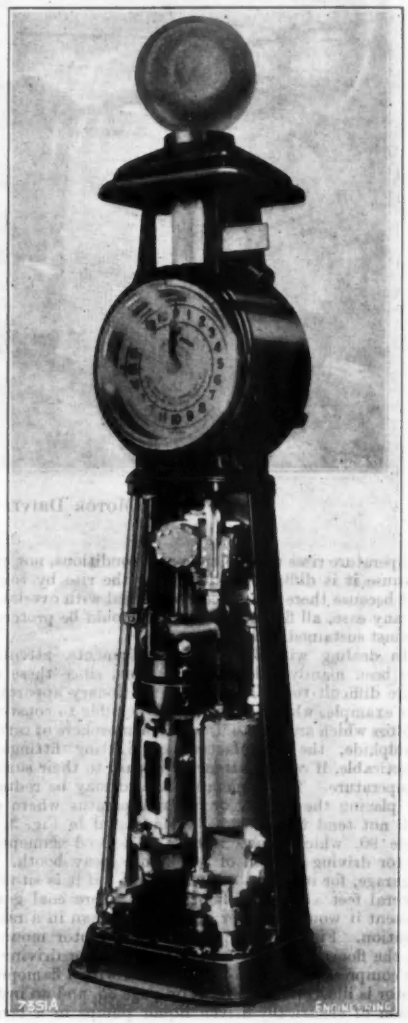


FIG. 1. PETROL PUMP WITH FLAMEPROOF MOTOR.

In some respects the designing of flameproof electrical apparatus for use in mines is fairly straightforward, as only one hazard, namely, fire-damp, has to be guarded against. The dangers arising from the presence of this gas have been extensively investigated under official direction and the risks are, therefore now well understood. The conditions which have to be complied with in constructing motors for use in gassy mines are rigidly laid down in such publications as the general regulations for the installation and use of electricity issued under the Coal Mines Act, 1911, British Standard Specification No. 741, and Mines Testing Memorandum No. 4. The authority administering these regulations is the Mines Department of the Board of Trade and the apparatus is tested and certified by the Mines Department Testing Station at Buxton. Motors so tested are entitled to bear a nameplate with the crown and F.L.P. (flameproof), certificate number. Apart from the hazard of fire-damp, electrical apparatus intended for use in mines must be designed so that it is capable of withstanding the rough usage to which it is likely to be subjected, and this may render desirable the use of steel construction.

The authority governing the use of flameproof electrical apparatus in general industry, as distinct from mines, is the Home Office, acting through the factory inspectors. Testing, however, is still carried out by the Mines Department Testing Station at Buxton, and the certificates are issued by the Mines Department of the Board of Trade. The regulations covering the use of such equipment are the Electricity Regulations, especially the memorandum (Form 928) by the Senior Electrical Inspector of Factories, the Factories Act, 1939, section 28, and the Mines Department Testing Memorandum, No. 4. The British Standards Institution has not yet published a specification in respect of flameproof construction for apparatus used in situations other than mines, although one is in preparation. In addition, there are memoranda issued by H.M. Stationery Office for the Factory Department of the Home Office. These give guidance for particular industries and the principal ones involving flameproof apparatus are set out in Table I. It will

TABLE I.—*Schedule of H.M. Stationery Office Memoranda.*

Hazard.	Form No.	Title, Etc.
1. Carbon Bi-sulphide	836	Memo. on Precautions against Danger by Poisoning, Fire, and Explosion in connection with use of Carbon Bi-sulphide in artificial silk, indiarubber, and other works. 1935.
2. Explosive powder	27337-34	Memo. on Electric Light and Power in Factories and Magazines for Explosives. 1934.
3. Dry Cleaning (Benzine)	824	Memo. on Dry Cleaning. 1934.
4. Cellulose ..	826	Memo. on Manufacture, Use, and Storage of Cellulose Solutions. 1936.
5. Petrol ..	—	Petroleum Consolidation Act, 1938. (Does not incorporate Electricity Regulations.)
6. Acetylene ..	1,704	Memo. on Safety Measures Required in the use of Acetylene Gas and in Oxy-Acetylene Processes in Factories. 1937.
7. Dusts, etc. ..	829	Memo. on Dust Explosions in Factories. 1930.
7a. Dusts, etc.	34-227	Report on Experiments into the Means of Preventing the Spread of Explosions of Carbonaceous Dust. R. V. Wheeler. 1935. (Supplementary to 7.)

be clear from what has just been said that the problem is not easy; many different gases and inflammable liquids and vapours have to be dealt with, and it is virtually impossible, therefore, for the rulings to be as specific as in the case of coal mines. The object of the various memoranda, in fact, would appear to be to point out the hazards that may exist in certain processes and only to debar the use of electrical apparatus where experience has shown it is essential to do so. For other processes and situations the policy is apparently to judge each case on its merits, as is indicated by the over-riding ruling in paragraph 27 of the Electricity Regulations, which reads "All conductors and apparatus exposed to . . . inflammable surroundings or explosive atmospheres . . . shall be constructed or protected, and such special precautions taken as may be necessary adequately to prevent danger in view of such exposure or use."

Many gases are encountered in industry, but the Mines Department Testing Memorandum No. 4 recognises three as testing media for different hazards, namely, Class I, methane or fire-damp; Class II, pentane or petrol vapour; and Class III, coal or coke-oven gas (60 per cent. hydrogen, 40 per cent. methane). Flameproof certificates are issued in respect of the first two only. The requirements of the third group are "provisional," and reports only are issued, regarding which Testing Memorandum No. 4 states, "It is to be understood that the reports now contemplated with respect to town's gas and coke-oven gas are not equivalent to the formal certificates of the Mines Department which are issued with respect to fire-damp and petroleum vapour, and that the structural requirements for the apparatus are provisional and as such are liable to alteration either in the direction of greater or less severity, as experience and the results of research may warrant. Nevertheless, these reports, if favourable, will be accepted for the present by the Factory Department of the Home Office as indicating that the apparatus is flameproof, when properly installed and maintained with respect to the gas or gases to be named in the report." Fig. 4, on page 90, shows an electrically-driven Askania regulator for coke-oven gas which complies with these conditions.

There is official recognition that acetone and cellulose-spray vapours come within the pentane group, but there is no official classification of the numerous other gas and vapours encountered in industry. It is necessary, therefore, to seek guidance based on the known

chemical and other characteristics of the gases and liquids concerned and Table II has, therefore, been prepared on this basis. The principal published figures are those of Statham, Rainford and Wheeler. Recently, also, much work has been done by the British Electrical and Allied Industries Research Association and the Electrical Section of the Safety in Mines Research Board. It appears that testing conditions are tending to become more rigorous, both as regards the number of consecutive explosions that have to be withstood without transmitting flame and the requirement that ignition shall be in the most hazardous position (usually side ignition). Factors of safety relative to the maximum safe gap are officially established in respect of methane, pentane and coal gas, and similar factors have been employed for other gases mentioned in Table II.

TABLE II.—*Schedule of Gases and Liquids.*

Hazard Classification.	Considered as a Lower Hazard, but included as a Desirable Precaution.	Remarks.
Methane : Methyl chloride ..	—	Use FLP. Group 1.
Pentane :		
Cellulose lacquer spray* (100 deg. C.); ethyl acetate*; methyl ethyl*	Amyl acetate*	Use FLP. Group 2.
Acetone; ethyl alcohol*; methyl alcohol*	Amyl alcohol*	,,
Benzene (benzol)*; ethyl butyrate; methyl acetate*	Butyl alcohol*	,,
Petrol; ethyl chloride; methyl cyclohexane	Butyl butyrate*	,,
Methylated spirits; ethyl formate; methyl formate ..	Butyl acetate*	,,
Naphthalene; acetaldehyde; propyl acetate*	Xylene (Xylol)*	,,
Toluene (toluol)*; cyclohexane; propyl alcohol* ..	Paraffin	,,
Ethane†; butane†; hexane ..	Blast-furnace gas	,,
Heptane; propane†	—	,,
Coal Gas :		
Coke-oven gas; carbon monoxide	—	Use FLP. Group 3.
Ether (100 deg. C.)†; water gas	—	
Hydrogen :		
Acetylene†; hydrogen sulphide	Butylene	Do not use electric motors.
Ethylene†; carbon bisulphide† (125 deg. C.)	Propylene	

Where temperature is indicated it is because of risk of auto ignition if this figure is exceeded.

* Those marked with an asterisk are constituents of cellulose solutions in official publications.
† Statham and Rainford, *Fuel in Science and Practice*, 1931.

The principal difficulty with which the designer has to deal in the more dangerous cases is that the radial clearance round the motor shaft becomes impractically small if the existing factors of safety are applied. The permissible working radial clearance round the shaft, in respect of coal gas, is 0·005 in., and normally it is difficult to make practical radial clearances very much finer than this. Labyrinth glands may be used to overcome this drawback and to withstand the pressure developed by the various gases, but the designer hesitates to employ them as it is not easy to establish a hard and fast figure for safety unless each gland is considered individually, and that is a lengthy process. The figure mentioned above is for ball and roller bearing motors, as these are now almost universally employed. It may be asked why all motors are not built to comply with the most difficult conditions. The answer is to be found partly in the sequence in which the rulings were established and partly in the desire to maintain as large clearances as possible consonant with the working conditions. An increasing number of motors are, however, being built for use with pentane or petrol vapour and are being certified for use in methane with the same clearances.

In some cases, attempts have been made to deal with the more dangerous gases by connecting the motor casing to a compressed-air supply so that no ignitable mixture can collect inside it. This method is not recognised in official publications although in the memorandum on dusts mention is made of utilising a supply of inert gas for the same purpose. If such a course were adopted, it would seem desirable not only to connect the air supply to the motor, but to the terminal box as well, as the latter is a place where an arc might easily start. The surface temperature of the apparatus is a risk which is mentioned in the case of cellulose, it being considered desirable that this should not exceed 100 deg. C. Flameproof motors have a normal temperature rise of 50 deg. C., but this is an internal temperature and the external temperature would be about 10 deg. lower. Assuming that, in this country the ambient temperature would not exceed 40 deg., a motor having a temperature rise of 50 deg. C. would still be safe. Apart from official rulings, however, it would seem undesirable to use motors with high temperature rises under flameproof conditions, not only because it is difficult to determine the rise by touch, but because there is less reserve to deal with overloads. In any case, all flameproof motors should be protected against sustained overloads.

In dealing with flameproof equipments, attention has been mainly paid to the motors, since these are more difficult to deal with than stationary apparatus. For example, while it may not be possible to construct motors which are safe to use in an atmosphere of carbon disulphide, the manufacture of lighting fittings is practicable, if careful attention is paid to their surface temperature. The flameproof hazard may be reduced by placing the motors or other apparatus where gas will not tend to collect, as is indicated in Fig. 3, on page 90, which shows a totally-enclosed flameproof motor driving the fan of a cellulose spray booth. In a garage, for instance, a motor is safer if it is situated several feet above the floor, while where coal gas is present it would be safer on the floor than in a raised position. Fig. 2 shows a flameproof motor mounted on the floor level in a colliery and used for driving an air compressor. A petrol pump fitted with a flameproof motor is illustrated in Fig. 1, on page 85, and an installation of electrically-driven liquor pumps in a benzol house is shown in Fig. 5, on page 90.

The different memoranda rule that the wiring for flameproof apparatus used in general industry must be drawn into heavy-gauge conduit. Recently, Testing Memorandum No. 4 has ruled that both ends of the conduit must terminate in a flameproof enclosure or "where one or more units coupled by a conduit can be excluded by position from the explosion hazard so as not to require a flameproof enclosure, the conduit where it leaves the hazardous area must be isolated by means of a terminal barrier in a flameproof junction box or other equivalent means." It should be noted that oil-immersed switchgear or control gear may, by the generation of hydrogen, constitute a hazard greater than the surrounding gas, and it would, therefore, seem a wise precaution in such instances to limit the hazard to the switch itself by using a sealing chamber at the switch end of the conduit. Incidentally, it is of interest to note that American regulations demand the use of sealing boxes wherever conduit is employed on flameproof industrial equipment. Wiring in conduit is one of the principal points of difference between mining and industrial practice. On mining motors, the use of conduit is only permitted in short lengths, such as from the motor itself to a closely adjacent switch mounted on the same rigid baseplate. On the other hand, the regulations lay down heavy-gauge conduit as a standard for industrial motors.

The certificate number may only be used on apparatus provided that no changes affecting its flameproof properties are made without special re-certification. Minor mechanical changes, which are external to the flameproof enclosure, may be made. The inclusion of removable plugs for gap measurement or drainage is not permitted, though "fixed" plugs with breather apparatus, the number and size of which have been fixed by experiment, can be employed. For most flameproof industrial applications squirrel-cage motors are used for reasons of simplicity, reliability and price. The motors are generally fan-cooled and it is only rarely that the objection is raised that the draught of air associated with them agitates the dust. Plain total enclosure is usually only economically possible in the small sizes of motor.

In addition to the hazard of explosive gases, it should be realised that there is a risk of explosion when certain dusts are present. This forms the subject of a memorandum on dust explosions in factories which is largely based on the experiments of Dr. Wheeler. In this, dusts are divided into three classes: Class I includes such dusts as sugar, starch and grain, which ignite and propagate flame readily, the source of heat required for their ignition being comparatively small, such, for example, as a lighted match. Class II comprises dusts from such materials as leather and oil cake, which are readily ignited, but which for propagation require a large source of high-temperature heat, such as an electric arc, or heat of long duration, such as the flame of a Bunsen burner. In Class III are dusts such as tobacco and bone meal, which do not appear to be capable of propagating flame under any conditions likely to occur in a factory. As far as this memorandum is concerned, flameproof motors are not generally demanded in industry, it being only necessary for motors to have a flameproof enclosure over the sparking contacts or slip rings, and the use of pipe-ventilated or ordinary totally-enclosed or totally-enclosed fan-cooled motors is indicated. In dusty situations, however, flameproof motors are often installed under Rule 27 of the General Regulations.

Doubt has been expressed in some quarters whether flameproof motors are really as suitable for a very dusty condition involving explosion hazards as are dustproof industrial motors. The reason is that the flameproof regulations permit the use of gaps between the flanges while these gaps are not used in the design of dustproof motors. This objection is not valid because although gaps are permitted the flanges generally fit more tightly than on an industrial dust-tight motor. In the memorandum on dust explosions, mention is made of the desirability of temperature rises not being excessive on electrical apparatus, although the temperatures indicated are above 100 deg. C. Tests, however, usually take place in clean surroundings, and it is desirable that reasonable allowance should be made for the accumulation of dirt, etc., under working conditions.

FLAMEPROOF MOTORS IN INDUSTRY.

MESSRS. THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, RUGBY.

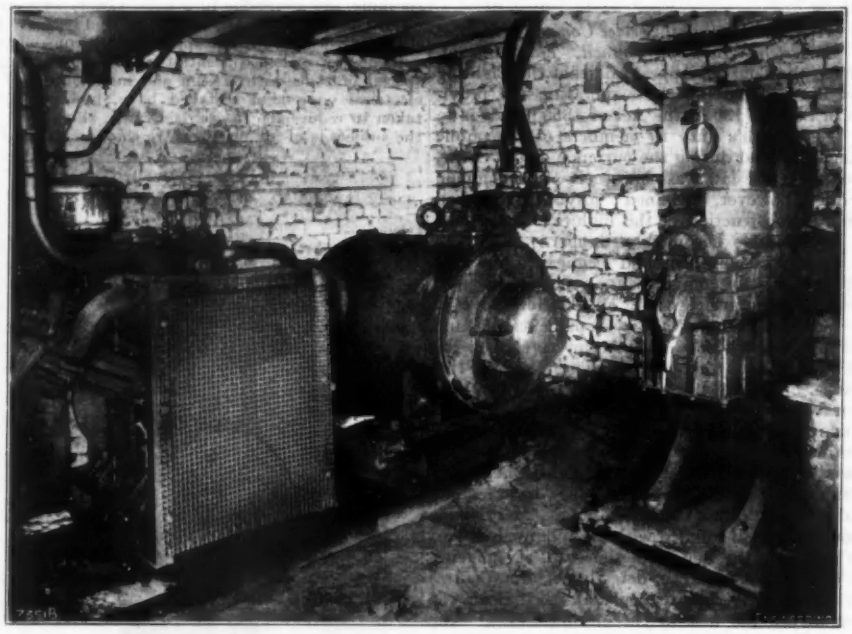


FIG. 2. MOTOR DRIVING COLLIERY AIR COMPRESSOR.

30-TON TRANSFORMER TRAILER.

MESSRS. R. A. DYSON AND COMPANY, LIMITED, LIVERPOOL.

FIG. 6. DETACHED FORECARRIAGE SUPPORTING REAR OF LONG LOAD.

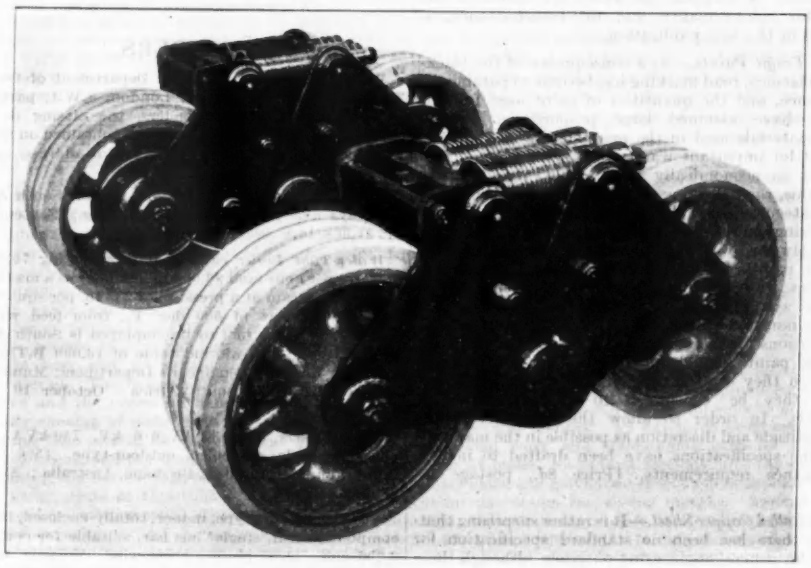


FIG. 7. REAR BOGIE WITH RUBBER SPRINGS.

30-TON EIGHT-WHEELED TRANSFORMER TRAILER.

THE steadily-increasing size of many modern engineering parts, such as electrical transformers, steam accumulators, boiler drums, and so on, while presenting no great difficulties of construction, does involve those of transport from the manufacturer's works to the site on which they are to be installed. Rail transit, in most of these cases, is precluded, not only by loading-gauge restrictions, but by the scarcity of suitable vehicles. In consequence, the heavy and bulky loads formed by the parts have to be transported by road, a condition necessitating vehicle design which causes the minimum of damage to the road surface, will meet surface irregularities, and will enable corners and cambers to be negotiated without risk of loss of stability with a load having a high centre of gravity. Considerable progress has been made in recent years in the design of these vehicles, several examples of which have been illustrated in our columns. One of the latest heavy load carrying vehicles is the unusual transformer trailer illustrated in Figs. 1 to 7, on Plate VII, and on this page. The trailer, which has eight wheels, has a working load capacity of 30 tons, and has been constructed by Messrs. R. A. Dyson and Company, Limited, 76-80, Grafton-street, Liverpool, 8, in co-operation with Messrs. Walter Denton, Limited, Manchester-road, Hyde, and that firm's associates.

Reference to Figs. 1 and 2, Plate VII, will show that the main platform is 22 ft. 6 in. long by 7 ft. 5 in. wide, and its surface is 2 ft. 3 in. above the road. A secondary platform at a higher level above the forecarriage is 8 ft. long and of the same width as the main platform. The total wheelbase is 29 ft. 5¼ in., this dimension being taken from the centre of the front wheels to the centre of the extreme rear wheel. There are, however, a pair of rear wheels on each side, the wheelbase of which is 3 ft. 8½ in., and the distance between their point of attachment and the front axle is 27 ft. 7 in. The overall length of the trailer is 33 ft. 10 in., and the unloaded weight is estimated at approximately 8·5 tons. Reference to Figs 3, 4 and 5, on the same Plate, will give, from Fig. 3, an idea of the general appearance of the trailer on a level road, coupled to a Foden tractor having a power-driven winch. The transverse flexibility of the front wheels, a characteristic contributing to lateral stability, is shown in Fig. 4. The two pairs of rear wheels have not transverse flexibility, but are arranged, as shown in Fig. 5, to swivel in a longitudinal vertical plane in order to meet major irregularities in the road surface. This swivelling movement is possible on both sides of a vertical centre line, as the different positions in which both pairs are jacked up with blocks in this view will make clear. The forecarriage swivels round a vertical central axis, while the axle of the rear bogie is rigidly attached to the frame, though it is detachable.

The construction of the main frame of the trailer will be clear from Figs. 1 and 2, but some comment on the wheel mounting is necessary. All the wheels are of the same diameter and width, and are fitted with giant solid twin tyres. Their section is clearly seen to the right of the plan, Fig. 2, which also shows that Timken tapered-roller bearings are fitted and illustrates the method of attaching the brake drums. The front wheels are mounted with each pair running on a common axle supported at its centre, all four wheels being in line transversely. Each wheel of the rear pairs, however, has its own axle carried at the ends in the bogie frame, and each pair of the wheels is in line longitudinally, *i.e.*, tandem fashion. The springing of the front and rear wheels is also different. The two front axles are each attached to a half-elliptical laminated spring of silico-manganese steel, so that there is one spring to each pair of wheels. In order to permit the tilting of the axles, as shown in Fig. 4, the spring must swivel with the axle. This is effected by means of the Woodhead trunnion device at both ends of the spring. This device is indicated at the left-hand of Fig. 1. The top leaf of the spring curls round a solid circular block and the one below it is turned upwards as shown. In the recess thus formed is a cylindrical block through which the pin attaching the spring to the forecarriage passes. This block is firmly secured to the block of the first leaf, but is free to rotate on its axis, *i.e.*, on a centre line parallel to the laminations of the spring. The whole assembly of spring, axle and wheels is, therefore, free to tilt transversely without impairing the damping action of the spring.

Though the trailer is, of course, well suited to the transport of any heavy load within its capacity, it was primarily designed for carrying transformers, the external fittings of which necessitate them being loaded in such a manner that the centre of gravity is on one side of the trailer. Such eccentric loading, in normal circumstances, would cause the vehicle to tilt towards the more heavily-loaded side, a condition which would be highly dangerous when it was running on an adverse camber; hence the adoption of the system of springing on the forecarriage just described. The patentees of the trunnion end system, Messrs. Jonas Woodhead and Company, Limited, 177, Kirkstall-road, Leeds, 4, have carefully worked out the deflections so that the springs are capable of meeting the most unusual running conditions likely to occur. The attachment of the axles to the springs is noteworthy. Difficulty has been previously experienced in securing axles to single springs, as opposed to double spring attachments, the parts wearing quickly and so giving rise to a peculiar form of lateral oscillation which occasionally built up to serious amplitudes. The trouble has now been eliminated by the insertion of a block into which the square axle is recessed at the top and the spring at the bottom. This arrangement is clearly shown in Fig. 1.

The method of attachment of the forecarriage to the frame is dictated by the desirability of constructing heavy-duty vehicles in such a way that they have a wide range of uses. To enable this to be done, the king-pin of the forecarriage in the trailer now under consideration is finished with a groove at the top, with which groove the sliding yoke seen at the left hand of Fig. 2 engages. This fork, it will be realised, can be permanently locked and, as it is not removable, the attachment does not involve the employment of parts which need unscrewing and may, in consequence, be lost. The transformation of the trailer into another form is readily effected, the operation consisting of withdrawing the fork, jacking up the front part of the trailer and running the forecarriage out of the way. The bolster plate and turntable are designed to fit the tractor portion of a Scammell articulated unit, so that when this portion is backed into place and locked the trailer forms an articulated attachment. This arrangement has certain advantages in very bad weather when it is difficult to get road grip with an ordinary tractor. As an articulated unit the trailer may, moreover, be run at higher speeds, provided, of course, that the nature of the load makes such speeds permissible. Conversely, the forecarriage can be removed and fitted with a bolster, a similar bolster being fitted to the back of another trailer of a Scammell unit. Very long loads, such as boilers or girders, can then be transported, the load itself acting as a reach. An arrangement of this kind is illustrated in Fig. 6, above, in which view a welded-steel vessel 47 ft. long by 12 ft. in diameter, made by Messrs. Babcock and Wilcox, Limited, Renfrew, and weighing 39 tons, is shown being transported. The rear unit is, however, not the same as that employed on the 30-ton trailer.

The method of attaching the rear wheels of the trailer is seen on the right in Figs. 1 and 2, an external view of its bogie being given in Fig. 7, above. The attachment consists of a square bar of 6 in. sides, on which the ends of the main frame rest and which is secured to the frame by through-bolts and brackets. The ends of the bar and cylindrical end form a pivot

for the roughly-triangular plates which carry the rear wheels. It will be clear from both Fig. 1 and Fig. 7 that these plates, in addition to being pivoted on a common centre, are coupled at their upper corners by spring gear. The bogie as a whole can move round the pivot as indicated in Fig. 3, and each wheel has independent movement, that is, independent as far as the spring compression will allow, relative to the other. The springs, which consist of alternate rings of steel and rubber, are, of course, always in compression and damp out shock to the frame. The wheel plates are ¾ in. thick and have bosses welded on for the pivot and other holes. The pivot bosses are fitted with bushes, as shown in Fig. 2. Transverse movement of the bogie is prevented by a sleeve and bolt locking a cap on the inner plates, the two sets of plates being held together by the axles, spring bars and three stays.

All eight wheels of the trailer are fitted with brakes of the internal-expanding type, have "Safeguard" liners made by Messrs. Gandy Belt Manufacturing Company, Limited, Wheatland Works, Seacombe. The brakes on the forecarriage are operated, as will be clear from Fig. 1, by means of twin Westinghouse vacuum cylinders, the vacuum being derived from an exhauster on the towing tractor. The brakes are automatically applied by gear on the tractor, depression of the usual pedal involving no additional effort on the part of the driver. For parking and emergency purposes, hand screw-operated braking is provided on the rear wheels. The arrangement of this gear will be evident from Fig. 2. The brakes are designed so that any one set has an adequate holding capacity for both the loaded trailer and the tractor, a feature providing a high factor of safety and the safest possible means of operation. When the forecarriage is detached and used for a long load, connection to the vacuum brakes is made by a flexible rubber tube, as seen in Fig. 6, near the safety chains, which are fitted between the two sets of wheels. The vehicle described above is an excellent example of the progressive policy of the heavy-haulage industry.

FIRE HAZARDS WITH ALUMINIUM PAINT.

For many years aluminium paint has been used for many purposes and latterly the range of its applications has steadily increased. In view of this, the contention recently raised in some quarters that the paint constitutes a fire risk and therefore should not be employed in places in which inflammable gases are likely to be encountered, needs careful consideration. It has been established, as a result of tests made by an aluminium-pigment manufacturer and confirmed by a recent investigation undertaken by the Safety in Mines Research Board, that, under certain conditions, it is possible to produce sparks by striking an aluminium-painted ferrous surface. This has been responsible for the assumption that, in the presence of inflammable vapour, a fire risk is established. It is emphasised in a statement issued by the Northern Aluminium Company, Limited, however, that a careful consideration of the facts reveals that four conditions must all be present together before such a risk becomes definite. In the first place, the paint must have been applied to a rust-coated surface, and, secondly, the paint medium must be either of such a quality as to undergo subsequent cracking or must have been broken down as a result of heating to a temperature of not less than 90 deg. C. In the third place, inflammable vapour in explosive concentrations must be present, and, finally, sparks are produced only when a paint surface of the kind represented by the first two conditions mentioned above is struck with a steel, bronze, or other hard implement.

From the standpoint of maintenance alone, no paint should be applied to surfaces on which loose rust is present; it is always necessary for rusty surfaces to be cleaned prior to painting, and it is also the general practice to apply a rust inhibitor as a first coat. In this connection, it need hardly be emphasised that, in factories in which explosive vapours or materials exist, maintenance receives very careful consideration. Furthermore, the Home Office regulations governing the precautions to be taken to eliminate causes of sparking, where inflammable vapours are present, are stringent, and the prevention of possible ignition arising from the use of aluminium paint does not appear to require more rigid regulations than those which guard against sparking by impact between ferrous implements or by other means. The investigations by the Safety in Mines Research Board are being continued and the publication of its findings will be welcomed. The information available, however, indicates that, while the conditions under which the use of aluminium paint becomes a fire hazard are limited, the adoption of this paint, where such conditions do exist, should be given the careful consideration accorded to other possible sources of sparking.

BRITISH STANDARD SPECIFICATIONS.

The following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 2*d.* including postage.

Stirrup Pumps.—A new specification in the Air-Raid Precautions Series, designated BS/ARP No. 33, contains a description of the performance of the stirrup pump and gives a method of test for the spray produced in its operation. The object of the test is to ensure that, when the spray is directed on to an incendiary bomb, in order to accelerate its rate of burning, no appreciable scattering of the burning material will result. [Price 4*d.*, postage included.]

A supplement to the above specification gives a complete set of drawings of a typical stirrup pump, which if correctly made of suitable materials, should comply with the requirements of BS/ARP No. 33. All essential dimensions are given and special attention has been paid to the points where failure occurred in earlier models. [Price 8*d.*, postage included.]

Colours for Railway Signal Glasses.—First published in September, 1935, a revision of specification No. 623, dealing with colours for signal glasses for railway purposes, has now been issued. The revision gives a slight re-grouping of the glasses and modifies some of the limits of the earlier specification. It should, perhaps, be pointed out that the data in the specification do not refer to the colour or brightness of the signal as seen by an observer, but to the colorimetric and photometric properties of the lenses or other glasses as measured under suitably-defined conditions in the laboratory. A diagram, on which are indicated the limits for colour-quality and for transmittance, is included in the new publication.

Road-Traffic Paints.—As a consequence of the black-out regulations, road marking has become of paramount importance, and the quantities of paint used for this purpose have assumed large proportions. Certain of the materials used in the manufacture of paint are required for important war work; hence they should be used as economically as possible. In order to secure this, road-marking paints have been graded into three categories as follows:—(*a*) Rapid-drying paint for markings on the carriageway; (*b*) longer-drying but reasonably hard-wearing paints for markings on kerbs; and (*c*) paints for gravel bins, railings, and other pavement obstructions, where rapid drying is not essential and where there is no appreciable wear. A recently-issued specification, BS/ARP No. 38, contains specifications for these three types, it being emphasised that the paints should only be used for the purposes for which they are intended and in no circumstances should they be considered to be interchangeable materials. In order to allow the manufacturer as much latitude and discretion as possible in the materials used, the specifications have been drafted to include performance requirements. [Price 8*d.*, postage included.]

Cold-Rolled Copper Sheet.—It is rather surprising that so far, there has been no standard specification for copper for general engineering purposes, although there is a useful series of specifications for copper for electrical purposes. This deficiency has now been made good by the publication of specification No. 899-1940, which deals with cold-rolled copper sheet and strip (half-hard and annealed) for general engineering purposes. The composition clause has been framed in such a way that an arsenical copper can be provided if desired. The tensile strength of the material is from 17 to 21 tons per sq. in. for half-hard material and from 13·5 to 17 tons per sq. in. for annealed material, in thicknesses from No. 3 S.W.G. (0·252 in.) and thinner, and in widths up to 42 in.

Leaded Gunmetal Castings and Ingots.—In the past there has been only one specification for a gunmetal alloy. This relates to 88/10/2 (copper, tin, zinc) gunmetal ingots (No. 382-1930) and castings (No. 383-1930). Two further specifications have now been issued, the first relating to 85/5/5/5 (copper-tin-zinc-lead) gunmetal alloys and the second to 87/9/3/1 (copper-tin-zinc-lead) gunmetal. The first publication is designated No. 897 and 898-1940 and the second 900 and 901-1940. Each publication comprises separate specifications for ingots and for castings, and the form of the specifications follows the lines previously established for the gunmetal specifications. The new standards have been based on proposals put forward by the Institute of British Foundrymen as a result of a considerable amount of experimental work carried out by one of their committees. The minimum ultimate tensile stress value of the 88/5/5/5 alloy is 12 tons per square inch, and that of the 87/9/3/1 gunmetal 14 tons per square inch.

PERSONAL.

The Minister of Transport has appointed Mr. R. H. Hill, C.B., to be Deputy Secretary to the Ministry in succession to Sir Alfred Robinson, K.B.E., C.B., who retired on August 1. Mr. Gilbert S. Szlumper has been appointed to succeed Mr. Hill as Railway Control Officer at the Ministry. Mr. Szlumper relinquished the post of general manager of the Southern Railway, at the outbreak of war, to become the Director-General of Transportation and Movements at the War Office. Sir Alfred Robinson, for the time being, will continue to assist the Ministry in connection with certain general questions arising out of war conditions.

The Minister of Transport has appointed Mr. Fleetwood C. Pritchard to be Public Relations Officer to the Ministry.

Mr. Campbell Murray, M.I.E.E., 122, Wellington-street, Glasgow, C.2, has taken over the consulting practice of Messrs. Walter Dixon and Company, consulting engineers, Blythswood Chamber, 261, West George-street, Glasgow, C.2, of which the late Mr. Frank Anslow was the sole partner.

The honorary degree of Master of Science has been conferred by Manchester University on Mr. B. A. G. Churcher, M.I.E.E.

Mr. Robert Robertson has been appointed chairman of the Clyde Valley Electric Power Company and its associated concerns, in succession to the late Mr. Charles Ker.

Mr. W. E. Pratt has been appointed manager of the Oriental Tube Company, Limited, West Bromwich, in succession to the late Mr. C. J. Sadler.

Mr. Edward Baynes, C.B.E., has been appointed secretary of the Association of Consulting Engineers (Incorporated).

TENDERS.

We have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Transport Truck, petrol-engine driven. South African Railways and Harbours, Johannesburg; September 3. (T. 21,008/40.)

Water-Tube Boiler capable of evaporating 70,000 lb. of water per hour (and 80,000 lb. per hour as a maximum), to produce steam at a pressure of 235 lb. per square inch, at a temperature of 600 deg. F., from feed water at 130 deg. F. The fuel to be employed is South African pea coal having a calorific value of 13,000 B.Th.U. per lb. City Electrical Engineer's Department, Municipality of Port Elizabeth, South Africa; October 10. (T.Y. 21,035/40.)

Transformers, two 33 kV/6·6 kV, 750-kVA, three-phase, 50-cycle, oil-cooled, outdoor-type. City Electric Light Company, Limited, Brisbane, Australia; August 9. (T. 21,062/40.)

Switchgear, unit-type, indoor, totally-enclosed, ironclad, compound-filled, single 'bus bar, suitable for controlling 2,200-volt, three-phase, three-wire, 50-cycle circuits. State Electricity Commission of Victoria, Melbourne; August 13. (T. 21,065/40.)

BOOKS RECEIVED.

The Metallurgy of Deep Drawing and Pressing. By Dr. J. D. Jevons. London: Chapman and Hall, Ltd. [Price 50*s.* net.]

Transactions of the Institution of Chemical Engineers. Volume 17. 1939. London: Offices of the Institution, 56, Victoria-street, Westminster, S.W.1.

Canada. Department of Mines and Resources. Mines and Geology Branch. Bureau of Mines. No. 797. *Investigations in Ore Dressing and Metallurgy. July to December*, 1938. Ottawa: Bureau of Mines, Department of Mines and Resources. [Price 50 cents.]

Empleo del Hormigón Poroso o Celular en la Construcción de la Vivienda Popular. Trabajo Presentado al Primer Congreso Panamericano de la Vivienda Popular, Realizado en Octubre de 1939, *en Buenos Aires.* By Profesor Ing. J. B. Borgarelli. Montevideo, Uruguay: Profesor Ing. J. B. Borgarelli.

United States War Department. Lake Series No. 1. (Revised 1939.) *The Port of Buffalo, New York.* Washington: Superintendent of Documents. [Price 70 cents.]

United States Bureau of Mines. Bulletin No. 421. *The Joseph A. Holmes Safety Association and Its Awards.* By D. Harrington, Louise Pedlow and Anna P. Brown. Washington: Superintendent of Documents. [Price 40 cents.]

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The decision of the Government that supplies of raw materials have increased sufficiently for a larger allocation to be made available for export is welcomed by manufacturers in this area. Makers of machinery, tools, and certain types of engineering products will be able to obtain a larger tonnage of steel, and so increase their production for export purposes. Increasing outputs are being obtained in most of the local staple trades. All types of raw and semi-finished materials are in strong demand, and producers of basic and acid steels are operating large batteries of furnaces to their full capacity. Many of these have been turning out record heats, working continuously for the past three months. Intense activity prevails in the heavy-machinery and engineering branches. Messrs. Davy and United Engineering Company, Limited, Sheffield, report that during the past year they have completed several important export contracts and have supplied a considerable number of mills, presses, and general engineering plants to British firms. This firm, it is understood, has taken certain initial steps to combine its Sheffield and Glasgow organisations by standardising workshop methods and routine as far as possible, but the plans they have in mind have to be carried out slowly until conditions return to a more normal state. Hollow forgings, boiler drums, and vessels capable of withstanding high pressures are in demand for various purposes. Boiler makers are busy, and have many valuable orders on hand. Sheffield works are supplying increased tonnages of high-efficiency steel to makers of all types of electric generating plant. Orders for concrete and cement-mixing machines are more numerous. Iron-ore and coal crushers are in better demand on both home and overseas account.

South Yorkshire Coal Trade.—Business in all types of industrial coal has been maintained at a high level. Locomotive coal is in greater demand and the consumption of smalls and slacks by electric power stations and gas-making works shows a further increase; big stocks are being built up by many works. House coal finds a good market, and cokes of all kinds are in demand.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The increasing demand for steel is utilising the resources of the Scottish steel makers to the full, but by maximum efforts at the works, combined with satisfactory supplies of raw materials, an excellent output is being secured. The munition works, shipbuilding yards and engineering concerns are all consuming heavy tonnages, so that there is little steel available for general commercial purposes. Structural engineers are busy and are pressing for deliveries of sectional material. The demand for black steel sheets is still heavy and the orders on hand are sufficient to ensure steady running of plant for a considerable time. Steel scrap has been coming into port in large quantities during recent weeks, and the tonnage collected throughout the country has been a material help. The minor repairs to plant, usual at this time of the year, were speedily carried out without much disturbance to production and full-capacity output is again general. The following are the current quotations:—Boiler plates, 15*l.* per ton; ship plates, 14*l.* 3*s.* per ton; sections, 13*l.* 13*s.* per ton; medium plates, rolled in sheet mills, ¼ in. and thicker, 18*l.* 7*s.* 6*d.* per ton; mild-steel black sheets, No. 21-24 gauge, close annealed, 19*l.* 7*s.* 6*d.* per ton; galvanised plain sheets, No. 21-24 gauge, 23*l.* 2*s.* 6*d.* per ton; and galvanised corrugated sheets, No. 24 gauge, 22*l.* 12*s.* 6*d.* per ton.

Malleable-Iron Trade.—The position in the malleable-iron trade of the West of Scotland has not altered and there are no indications of any change in the near future, as all the works have numerous orders on hand. The demand for re-rolled steel bars continues on a large scale, all plant being fully occupied. Some necessary repairs were carried through lately, so that maximum outputs may be maintained throughout the autumn. Raw material is plentiful, as good consignments of semi-manufactured steel from overseas have arrived here in recent weeks and supplies from local works have also been very satisfactory. The market prices are as follows:—Crown bars, 15*l.* 2*s.* 6*d.* per ton; best iron, 15*l.* per ton; No. 3 bars, 13*l.* 7*s.* 6*d.* per ton; No. 4 bars, 13*l.* 12*s.* 6*d.* per ton; re-rolled steel bars, tested, 15*l.* 11*s.* 6*d.* per ton; and untested, 15*l.* 8*s.* 6*d.* per ton; angles and tees, 4 in. and under, tested, 15*l.* 1*s.* 6*d.* per ton, and untested, 14*l.* 18*s.* 6*d.* per ton; all for home delivery.

Scottish Pig-Iron Trade.—Activity is general in the Scottish pig-iron trade and the full output of all the furnaces in blast is going rapidly into consumption. The demand from the steelworks is very heavy but foundry grades are moving slowly. Ore supplies are satisfactory and stocks are ample for all requirements.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—There is no diminution in the pressure for the supply of iron and steel for needs of national importance, but the aggregate production is maintained at a very high level. Stringent enforcement of the control of distribution scheme is now regularly providing consumers directly engaged on work of national importance with tonnages sufficient for their actual requirements, and releasing moderate additional parcels of material for export. The usual home customers are still anxious to place substantial orders and are hoping for an early improvement in deliveries of commodities for ordinary industrial purposes.

Cleveland Iron Trade.—Conditions in the Cleveland pig branch of trade are unchanged. The small intermittent make is rapidly taken up, and is not sufficient for the moderate needs of the founders, but deliveries of Midland iron remain satisfactory and occasional small quantities of Scotch brands are still coming to hand. While there is no actual shortage of foundry iron, supplies are insufficient to permit any replenishment of stocks. The stabilised quotations for Cleveland pig are at the equivalent of No. 3 description at 120*s.*, delivered within the Tees-side zone.

Hematite.—The heavy make of East Coast hematite is passing rapidly into use and the large and increasing demand is taxing the resources of producers. Customers with extensive running contracts are calling for full supplies and provision has to be made for the increased absorption of tonnage at the makers' own consuming plants. There is very little free tonnage; makers have hardly any for sale, and the small quantities which merchants have at command are allocated to their regular customers. The recognised market values remain at the level of No. I grade of hematite at 131*s.*, delivered to North of England buyers.

Basic Iron.—The nominal price of basic iron remains at 113*s.* Output is maintained on a large scale, and suffices for the claims of producers' adjacent steel-making plants, but leaves little for other consumers.

Foreign Ore.—Stocks of foreign ore are at an exceptionally high level and imports are regular and satisfactory.

Blast-Furnace Coke.—As local users of Durham blast-furnace coke have made provision for their requirements as far ahead as they consider necessary, and sellers are not inclined to add to their well-filled order books, transactions in furnace fuel are few. Prices are based on good medium qualities at 33*s.* 5*d.* at the ovens.

Manufactured Iron and Steel.—The substantial make of semi-finished iron and steel, supplemented by considerable imports from America, provides ample tonnage for the re-rolling mills, the output of which is exceptionally large. Manufactured-iron firms have more work on hand than recently, and finished-steel producers have contracts to execute that will ensure full activity of their plant for several months. An extensive programme of constructional work and shipbuilding calls for heavy deliveries of plates, joists, and sections, and the orders placed for black and galvanised sheets will necessitate the maximum production for several months. Among the principal quotations are:—Soft steel billets, 10*l.* 10*s.* to 10*l.* 15*s.*; hard billets, 11*l.* 17*s.* 6*d.*; joists and angles, 13*l.* 13*s.*; heavy plates, 14*l.* 3*s.*; and boiler plates, 15*l.* 0*s.* 6*d.*

Scrap.—Large cargoes of iron and steel scrap have arrived and as further substantial supplies are promised and the collection campaign has been successful, consumers are not likely to have cause for complaints of shortage.

PROPOSED MINISTRY OF BUILDING.—According to a speech made by Mr. J. Marchbank, general secretary of the National Union of Railwaymen, plans for a Ministry of Building, to be set up after the war, are under consideration.

INSTITUTION OF ELECTRICAL ENGINEERS.—The following scholarships have been awarded by the Institution of Electrical Engineers for 1940: *Duddell Scholarship*, Mr. D. La W. W. King (Northampton Polytechnic); *Silvanus Thompson Scholarship*: Award for 1938 renewed to Mr. H. Darnell (Liverpool University) for a third year. No new award made this year. *William Berdie Esson Scholarship*, Mr. C. H. Bickerdike (London and North Eastern Railway); *David Hughes Scholarship*, Mr. J. H. Nicoll (Merchant Venturers' Technical College, Bristol); *Salomons Scholarships*, Messrs. H. Rosenbrock and P. H. W. Whyman (University College, London); *Thorrowgood Scholarships*, Mr. R. J. Post (London Passenger Transport Board), and Mr. R. P. Gasson (Southern Railway). No award of the Ferranti or Swan Memorial Scholarships or of grants from the War Thanksgiving Education and Research Fund have been made this year.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—A suggestion, which has met with a good deal of support in the South Wales coal trade, has been made locally, that the work of the Coal Commission, in valuing the coal royalties so as to apportion compensation under the Coal Act, 1938, should be suspended. It has been pointed out that the Commission were solving the problems of distributing royalties to thousands of owners and the necessary amount would be borrowed to buy out property in unworked coal and other minerals. The present, it was claimed, was not a time to continue with such a scheme, especially since the Government had taken over vast powers of control over individuals and property, and the operation of the Act should be suspended until after the war. Mr. Iestyn Williams, joint secretary of the Monmouthshire and South Wales Coalowners' Association, supporting the proposal, said that before the war the coalowners had offered every assistance to the regional valuation board, but owing to the pressure of the depleted colliery staffs, the owners had now stated that they could not give any help from their staffs to the regional board so long as the emergency lasted. The feature on the market during the past week has been the sustained activity in the home trade. Demand from this source was maintained at a very high level, due to the industrial activity now taking place in all parts of the country, and the heavy deliveries which were being made enabled collieries to maintain work at the mines on strong lines; the tone was consequently very steadily maintained. Export business continued to come in quietly, although there were signs of expansion in the Spanish trade in the near future. Buyers in this direction were showing a greater interest than had been the case since the conclusion of the Spanish civil war, and it was understood that some large-scale contracts were under consideration. Best large descriptions continued to find a steady outlet, while the popular sized descriptions remained in limited supply for shipment, and the tone was consequently very firm. The bituminous small kinds attracted fairly good attention, but the dry grades were in need of further business. Cokes were active and strong.

The Iron and Steel Trade.—Activity in the iron and steel and allied industries of South Wales and Monmouthshire were maintained at a high level last week. The tin-plate trade was adversely affected by the decision to ban tin-plate packings for certain commodities, but other sections continued to find a brisk request. Works were again engaged almost to full capacity and order books were well filled ahead.

STEAM-RAISING PLANT ACCESSORIES EXPORT GROUP.—Mr. A. M. Fairbairn has been made chairman of the Steam-Raising Plant Accessories Export Group. Mr. F. N. Marcy is the secretary, and the address of the office is 14, Old-square, Lincoln's Inn, London, W.C.2.

CENTENARY OF AMERICAN RAILWAY-COACH WORKS.—The centenary of the Berwick Works, Pennsylvania, of the American Car and Foundry Company, has recently been celebrated. The works were originally founded in 1840 for the manufacture of ploughs, and during the celebrations it was announced that, since the formation of the American Car and Foundry Company in 1899, 230,000 railway coaches had been built there.

REFRIGERATION CABINETS FOR STORING DURALUMIN RIVETS.—The manipulation of Duralumin in aircraft and other factories is greatly facilitated by the storage of the metal in refrigerators to retard the age-hardening process. It has been found, for example, that if rivets are maintained at a temperature of about −10 deg. F., after heat-treatment and quenching, they remain in a workable condition for considerable periods. Refrigeration cabinets for storing Duralumin rivets have recently been supplied to several firms by Messrs. Coldair, Limited, an associated company of Messrs. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. Cabinets recently furnished to Messrs. Gloster Aircraft Company, Limited, are designed to facilitate rapid loading and unloading of the low-temperature compartment with the minimum rise of temperature, arrangements having been made to maintain an internal temperature of from −10 deg. to −15 deg. F., with a room temperature of 80 deg. F. The cabinets are of heavy-gauge material, and each has a capacity of 2·9 cub. ft. The galvanised-steel storage compartment, which measures 22 in. by 10½ in. by 21½ in. deep, holds 500 lb. of rivets at a filling. The overall dimensions of the cabinet are 4 ft. 4 in. long by 2 ft. 1 in. wide by 2 ft. 8 in. high. The cabinet is insulated with 4 in. of compressed-cork, a galvanised mild-steel working top, thermostatic temperature control, and a dial thermometer. The equipment comprises a ¼-h.p. twin-cylinder compressor and ¼-in. solid-drawn copper cooling coils.

INDUSTRIAL USES OF FLAMEPROOF MOTORS.

MESSRS. THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, RUGBY.

(*For Description, see Page* 85.)

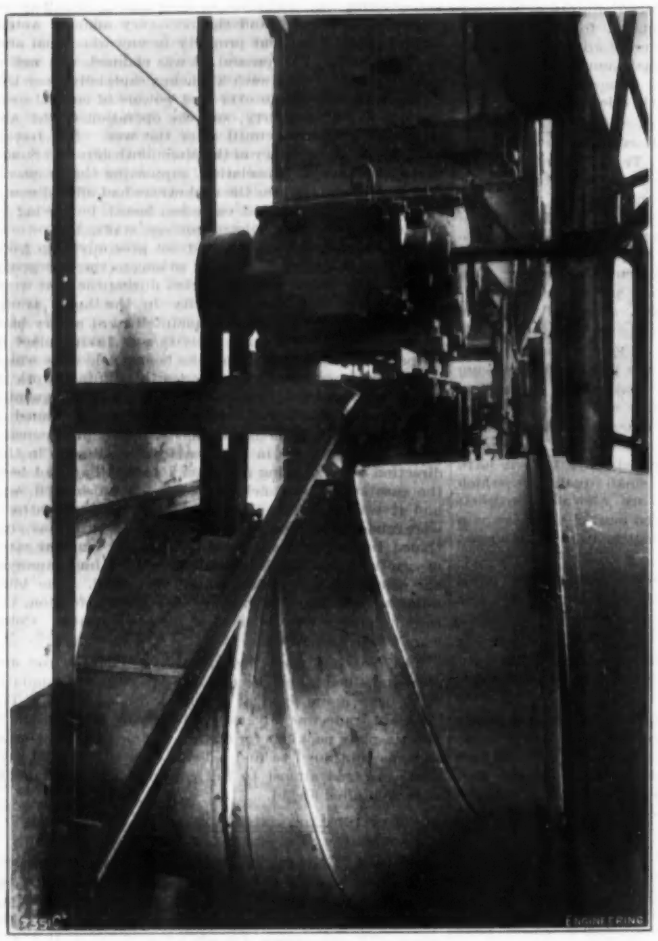


Fig. 3. Motor Driving Fan of Spray Booth.

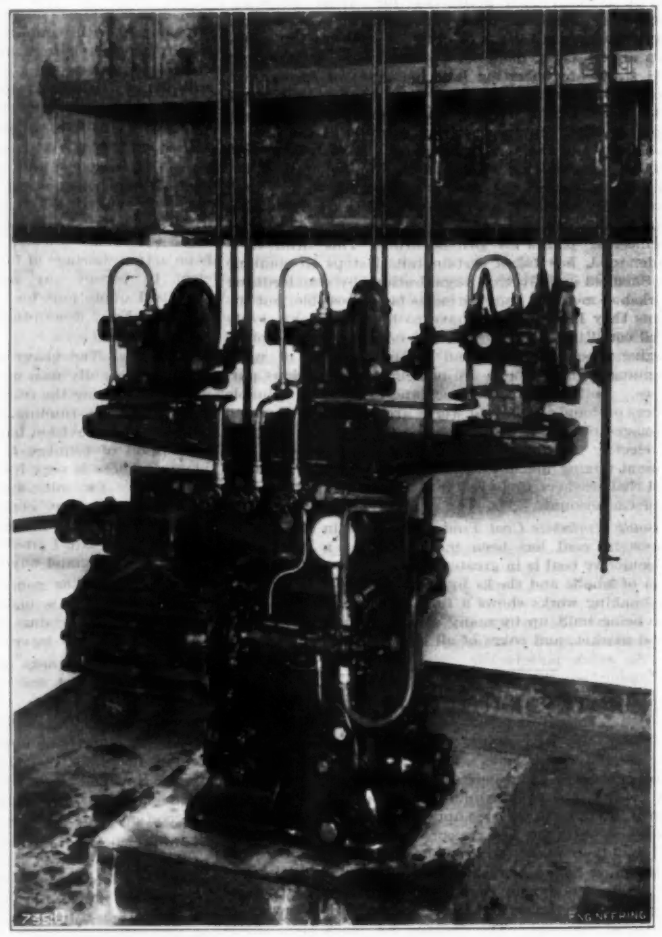


Fig. 4. Askania Regulator for Coke-Oven Gas.

IMPROVED CONSTRUCTION OF HIGH-POWER ELECTRIC LAMPS.

Of the many problems that have to be considered in constructing tungsten-filament lamps with ratings from 2 kW to 10 kW, the most important is the bringing of the heavy leads required into the bulb. In certain types this is effected by using the well-known bi-post construction in which the usual lamp cap is replaced by hollow copper posts. These posts, in turn, support nickel channel pieces, which carry the filament system. In other types of lamp, such as those used in lighthouses, the filament system and its supports are heavier and the centre lengths, from which the light is emitted, are greater than normal. Hitherto, lamps of this pattern have incorporated modifications of the conventional pinch seal, which is used on general-service lamps. Two pinches are employed, each of which carries two leads in parallel, and these leads act not only as conductors, but, together with the glass rods, as supports of the filament system.

This design has been in use with very slight modification since 1924, and though it has proved satisfactory in shore lighthouses, it is hardly robust enough for the more severe conditions encountered on light-ships. Messrs. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, have, therefore, developed a new method of bringing the heavy leads into the bulbs. This, we understand, has already been successfully applied to standard 3-kW lighthouse lamps, and will be gradually extended to all high-power lamps for which it is suitable. The method is known as the "inverted bi-post," and is distinguished by the fact that the hollow copper posts are now inside instead of outside the lamp. The leads from the standard screw cap are fitted inside these posts, which are joined to the two extremities of a U-shaped pinch. In this way, a gastight glass-to-metal joint is obtained in the usual way. Heavy channel pieces bolted to the posts carry the filament system, which has also been strengthened by shortening and stiffening the supports. The complete mounting is sealed into the bulb, which is exhausted and filled by the usual methods.

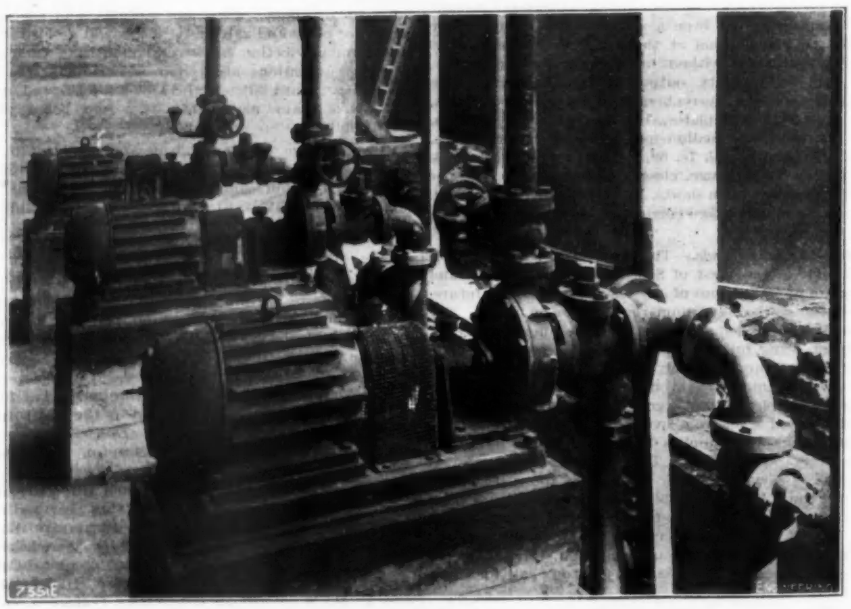


Fig. 5. Liquor Pumps in Benzol House.

30-TON EIGHT-WHEELED TR

CONSTRUCTED BY MESSRS. R. A. DYSON AN CO

(For Descripti, see

Fig. 1.

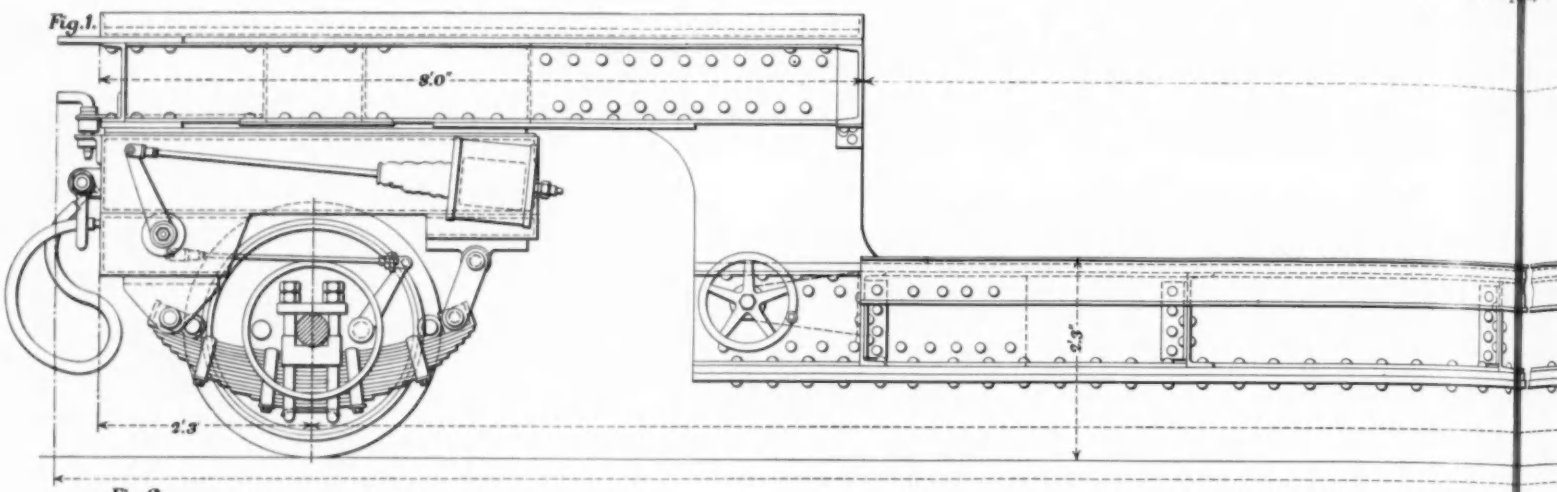
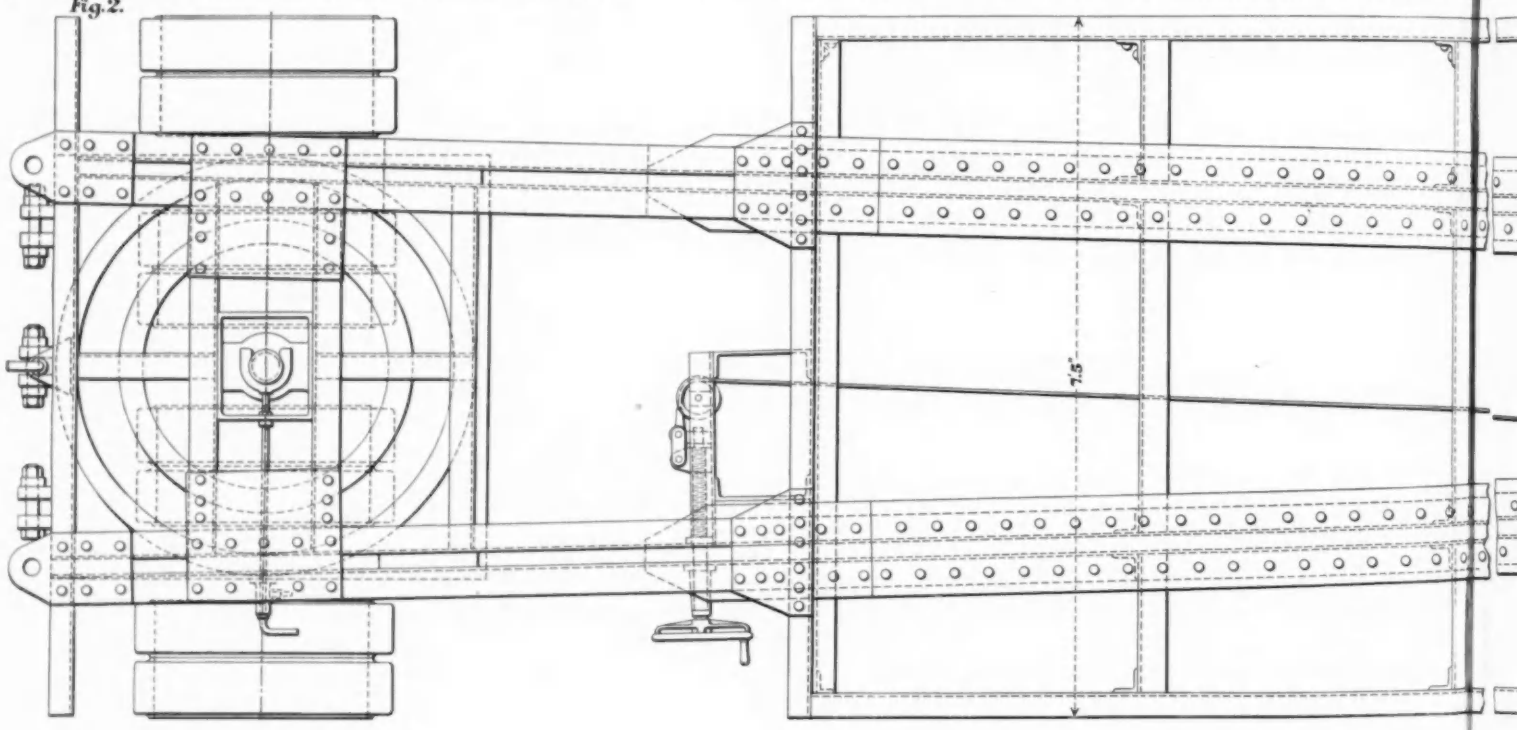


Fig. 2.



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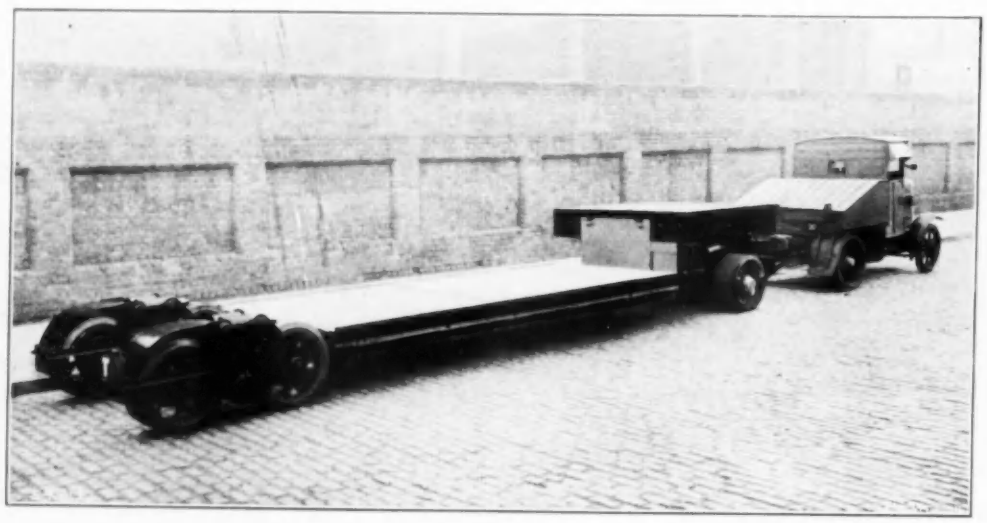


FIG. 3. TRAILER WITH TRACTOR ON LEVEL SURFACE.

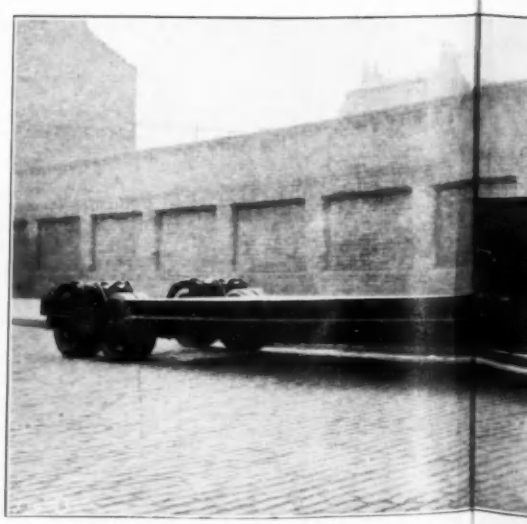
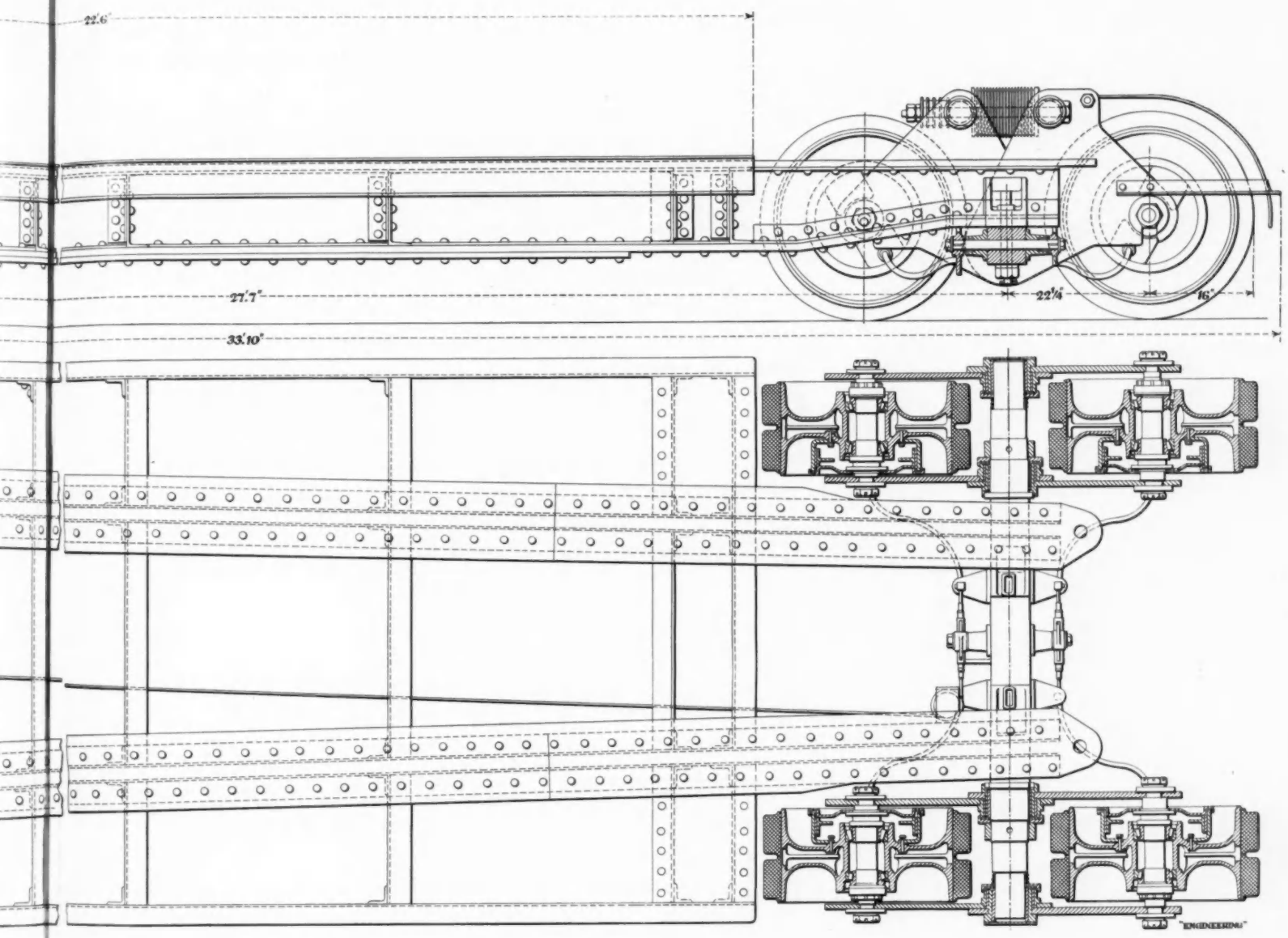


FIG. 4. TRAILER WITH FORECARRIAGE WHE

LED TRANSFORMER TRAILER.

SON AND COMPANY, LIMITED, ENGINEERS, LIVERPOOL.

r Description, see Page 87).



CARRIAGE WHEELS TILTED TRANSVERSELY.

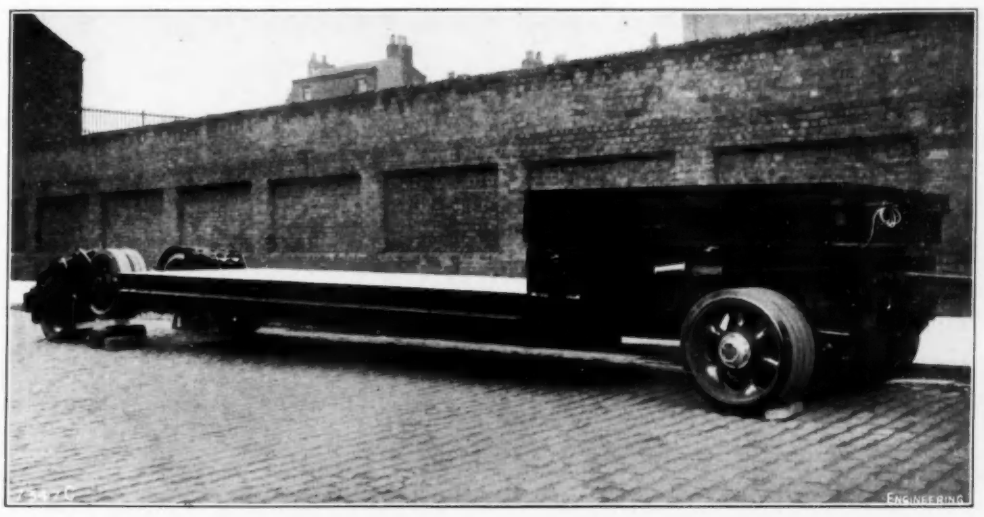


FIG. 5. TRAILER WITH REAR WHEEL ASSEMBLIES TILTED LONGITUDINALLY.

UNIV. OF MICH.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, AUGUST 2, 1940.

VOL. 150. No. 3890.

THE CO-ORDINATION OF GOODS TRANSPORT.

THE decision of the Minister of Transport, to take no action on the recommendations of the Transport Advisory Council for the better co-ordination of road, rail, canal and coastwise goods transport, was probably inevitable in the light of the changes in the national circumstances during the past two months. In a sense, indeed, the whole idea of appointing a committee, in time of war, to examine and report upon an undertaking so extensive as the reorganisation of a nation's transport, now appears to belong to a bygone era when war was regarded as necessarily a protracted affair, offering ample scope for such works of reconstruction. The special committee has worked quickly, all things considered, but not so quickly as events have moved; and the problems which it was appointed to investigate so recently as February 29 have now been superseded by others, arising from the German occupation of the whole European coastline from the Arctic Circle to the Pyrenees, which may demand, at any moment, changes in transport organisation far more sweeping than anything then contemplated. Nevertheless, the report is now a matter of record, backed by the authority of the Transport Advisory Council, and the subject with which it deals may be reasonably expected to come up again for consideration at some future date; possibly under pressure from interests which do not realise, or choose not to realise, that the investigation was specifically related by the terms of reference to war-time conditions, and "existing conditions" at that. It is desirable, therefore, to examine the recommendations made, even though there is no immediate prospect of their adoption.

The appointment of the committee originated in a letter sent from the Ministry of Transport to the Transport Advisory Council on February 7, 1940, stating that representations had been made to the Minister "from various responsible quarters" that there was a strong case for an independent review of the distribution of traffic between the different forms of transport in the country, including coastwise shipping. The Minister therefore invited the Transport Advisory Council "to consider whether those whose business it is to provide the different forms of public transport of goods in this country can, by some substantial re-arrangement of their methods of working in time of war (as a result of agreement among themselves or of Governmental direction, including direction as to the allocation of traffic), offer to the public more efficient and more economical services than those which are at present available." It was made clear in the letter that the Minister wished the questions to be considered "specifically on a war-time basis" and that "any recommendations made should in no wise prejudice the post-war position of the several parts of the transport industry." The Council, at a special meeting held on February 29, 1940, appointed a committee to consider and report, slightly modifying the conclusion of the terms of reference; in place of the words ". . . offer to the public . . ." and onwards, was substituted ". . . provide in the national interest more efficient services than those which under existing conditions are likely to be available." It will be seen that the modification was one of some importance.

The committee consisted of the Rt. Hon. Sir Arthur Griffith-Boscawen, P.C. (chairman), Mr. Sidney E. Garcke (deputy chairman), and fourteen other members, representing the railways, road transport, canals, coastwise shipping, and labour and trading interests. Eleven meetings were held, and, in addition to examining various witnesses, the committee considered memoranda from the Ministries of Transport and of Shipping, the Chamber of Shipping of the United Kingdom (Coasting Liner Section), the Road and Rail Central Conference, the Traders' Co-ordinating Committee on Transport, the Canal Joint Committee, the National Conference of Road Transport Clearing Houses, the Road Haulage Central Wages Board, and other interested parties.

The problem, simply stated, was to ensure that all four of the main means of internal transport should be used to the fullest possible extent permitted by war conditions; that the organisation of each branch should be efficiently maintained, despite fluctuations in volume of transport, and should be able to resume its normal position on the return of peace. No control existed, however, for the purpose of dividing the traffic between the four forms of transport, with this end in view. The operation of road vehicles was, and is, restricted by the necessary limitation of fuel supplies, thus effecting an indirect control, not applicable to the other three forms of transport; but the resultant diversion of traffic was a diversion from the road only and, in any case, the machinery for fuel allocation was not designed to serve as a means of traffic allocation. The control of coastwise shipping by the Ministry of Shipping applied directly to the ships and thus indirectly to their cargoes; but this, also, was in no sense a control over the distribution of traffic among the four forms of transport. Some control over the allocation of certain traffic was exercised by the Ministries of Food and of Supply, by the Services, and by some Government departments; but there was no co-ordination of these piecemeal controls, which were relatively limited in scope.

The Committee felt that a definite allocation of traffic between the four branches would contribute materially to the provision of a more efficient transport service. It could be brought about, they observed, either by imposing restrictions on consignors or by mutual agreement between the four transport divisions. The first-named method, though probably the more effective, would involve an immense preliminary classification, whereas the latter could be put in train at once. If the plan of a voluntary arrangement were adopted, it would be necessary to set up some central organisation overriding, and perhaps replacing, the existing sectional controls, and advised by local committees of any special factors operating in their areas.

The report recommends that the central committee should be as small as possible, and considers that it must be composed of persons who are able to remain in practically continuous session; preferably, one member from each of the four branches of transport, with an additional member to represent "the ancillary users of goods vehicles,"

a representative of the Ministry of Transport, and another from the Ministry of Shipping. The two Ministry members should have the maximum possible authority, to avoid unduly frequent reference to their respective departments. An independent chairman, preferably someone able to devote his whole time to the committee, should be appointed by the Minister of Transport in collaboration with the Minister of Shipping. Each Civil Defence Region should have its own regional committee, with an independent chairman. "If, as we recommend," the report continues, "these committees are to deal with arrangements made between the four branches of transport and not to impose direct restrictions on the consignors of goods, it does not seem necessary that traders should be represented"; a point of view on which, it is possible, there might be some difference of opinion, even though the proposal is added that the traders should set up a separate committee to watch their own interests, and that "contact with the central committee could be effected through the exchange of memoranda, by means of a joint committee of the two bodies, or by the attendance of the chairman of the traders' committee at meetings of the central committee as required." A similar arrangement is suggested for dealing with labour problems.

During their consideration of the inland waterways, the committee were informed that this industry had asked the Government to take over the canals and other waterways, with a guarantee of net receipts, as was done in 1916. On the present occasion, however, the Minister of Transport stated that the Government could not accede to the request. As negotiations were still proceeding in connection with certain counter-proposals put forward by the Minister, the committee did not discuss this branch further in their report. They did consider, however, the position of coastwise shipping, which they found to be experiencing a shortage of traffic, except in the case of the larger coasting tramp steamers. They observed that the coasting-liner trade thought that voluntary allocation of traffic would not be effective so far as their services were concerned; but, while the committee were not prepared to recommend the compulsory allocation of traffic to coastwise shipping, they considered that their proposals for closer co-ordination in voluntary allocation should have the desired effect of promoting fuller loading of such vessels.

Summarising the proposals, it will be seen that they consist of (*a*) a central committee to advise the Minister of Transport and to plan the best use of transport in advance of a possible "serious emergency"; (*b*) regional committees, with independent chairmen, in the several civil defence areas; (*c*) similarly-organised sub-committees where necessary. The regional committees and sub-committees would have the duty of effecting local agreements for the allocation of traffic, advising the central committee, keeping in touch with the Regional Transport Commissioners, and dealing with appeals from the local agreements. The point is made that, in arriving at these agreements, due attention should be given to "all relevant considerations, including cost of transit."

The decision of Sir John Reith, the Minister of Transport, not to adopt the recommendations was based primarily on the altered conditions since the inquiry was instigated, and the consequent doubt whether the results to be expected would be commensurate with the considerable task of setting up the necessary machinery. The Transport Advisory Council were reminded that powers already exist for the compulsory allocation of traffic under war conditions: rail traffic, by virtue of the Government control of railways; road traffic, under various emergency regulations; and the control of docks and harbours, by the Port Emergency Committees, which would act under the Ministry's orders in the event of any major diversion of shipping. It was felt, moreover, that, if the report were adopted, it would probably prove necessary to go much farther in the application of controls than the committee proposed to do. In view of all these considerations, therefore, the Minister concluded that "the attempt to make such a drastic change in the method of control of transport in this country would not be justified."

HIGH-VOLTAGE DISTRIBUTION IN RURAL AREAS.

The natural development of electricity supply in this country has been from the urban to the rural districts; in other words, from the densely-populated areas to those where the potential consumers are more widely scattered. There are several fairly obvious reasons for this fact. Early legislation rigidly limited the spheres of influence of both privately- and publicly-owned undertakings, especially the latter, within local government boundaries and, though means later became available whereby these limitations could be overstepped, there was little temptation to do so. It was equally natural that the load should be sought in those residential, shopping and factory areas which were already built up, though in many cases the word "sought" was a misnomer, since prospective consumers were left to make applications for connection rather than canvassed to do so. The campaigns to attract greater support, of which so many have been inaugurated in recent years, were at that time practically non-existent; and progress was a matter of natural growth which, of course, varied a good deal in its incidence, depending on the existing local conditions.

The history of what has taken place during the past twenty years to alter the original position is well known and need not be recounted in detail. Suffice it to say that legislation, business enterprise and public demand have all combined, not only to bring about an intense development in urban areas, but to make a supply of electricity available in most country districts, even in those where, in the nature of things, the load can never be very large. This movement has been assisted by the concentration of generation in a few large power stations, a policy which, willy-nilly, has relieved those undertakings which supply rural districts from the expense and responsibility of operating their own plant. Rural development, none the less, has had to be conducted on rather different lines from that which is possible in towns. In the streets of urban areas, all the inhabitants are potential consumers, even if they are not already connected to the mains. It is possible, therefore, to estimate the load requirements fairly closely and, without contravening the tenets of economic orthodoxy, to plan ahead in designing and laying the distribution systems.

In rural areas, on the other hand, it is a question of preparing an economic scheme for isolated villages and farms which, in any event, cannot provide large blocks of load; and while, latterly, this problem has been tackled with enterprise in many parts of the country, undertakings have adopted a sound policy in reducing their capital expenditure on these ventures to a minimum, though it may happen sometimes that the load will follow the supply in amazing quantities. One of the results of this enforced economy has been the employment of medium- and high-tensile steel conductors for the overhead lines, and at one time there seemed some prospect that this policy would be continued, as progressively "thinner" areas became due for development. In any event, however, to employ steel instead of copper is merely to make the best of a bad job and can only be justified in cases of real necessity. This may be emphasised by drawing a brief comparison between the two metals. For equivalent cross-sectional area, copper has, roughly, eight to ten times the carrying capacity of steel, the actual proportion depending upon the current density and the electrical characteristics of the latter material. Copper conductors also have a much longer life, and the balance in favour of their use has recently been further depressed by the Electricity Commissioners in allowing a reduction in the ice loading on high-tension conductors from $\frac{3}{8}$ in. to $\frac{1}{4}$ in. On the other hand, steel has the greater tensile strength and, therefore, its use enables longer spans to be employed, thus reducing difficulties with regard to both wayleaves and rentals. For these and other reasons it still finds supporters, while a third school favours the use of copper-cored steel in an attempt to maintain long-span construction and at the same time to obtain some part of the additional capacity offered by a copper line. It must be remembered that the low first costs of a steel line are offset by higher operating losses, and that, as the load increases, the use of copper is likely to become more economical.

High-voltage distribution in rural districts has been much facilitated by the adoption of a system which enables the necessary conductors to be carried on the same poles as the low-voltage distributors. This step forward has been made possible by the co-operation of the Postmaster-General and the Electricity Commissioners, and is permitted where the maximum operating voltage to earth is 6·6 kV. The original idea behind this policy was to enable additional feeding points to be provided at a low cost, though its adoption has been much assisted by the permitted reduction in ice loading, to which reference has already been made. In addition, certain of the original restrictions regarding special protection where high-tension conductors are erected along or across roadways have been modified; and the requirements where high-tension and low-tension lines are erected on the same poles have been relaxed. The Postmaster-General, who has sometimes been a thorn in the side of those wishing to erect overhead lines for the supply of electrical energy in neighbourhoods of "weak current" systems, has consented to the reduction of the distance between high-tension lines and Post Office lines and to the attachment of telephone subscribers' lines to the power-line poles. The attachment of low-voltage service wires to Post Office poles is also permitted, as is the reciprocal use of Post Office and power-line poles for flying-stay purposes. Further concession in the design of cradle guards and other fittings have been made.

These changes, of course, must be accompanied by such alterations in the design of the lines themselves as experience has shown to be necessary, especially with a view to obtaining flexibility as regards route, adaptability for isolated supplies, margin for load development, reliability and low upkeep cost, and simplicity of construction. These factors are discussed by Mr. K. L. May, in a paper on "High-Voltage Distribution in Rural Areas," which appears in the current issue of the *Journal* of the Institution of Electrical Engineers. In covering such matters as poles, clamps, bonding, conductors, span lengths and loading, the paper places on record the author's experience gained on the staff of Edmundson's Electricity Corporation, an undertaking which, as is well known, has carried out much pioneer work in this field. He also surveys the possibilities in rural development which are opened up by the use of combined high-voltage and low-voltage distribution lines, and points out that the initial cost of such a scheme, even after allowing for smaller low-voltage conductors, is often no less than for a standard low-voltage scheme. Generally, where a single-phase high-voltage/low-voltage scheme can be used, instead of a three-phase low-voltage system, the cost will be reduced; but where three-phase high-voltage is necessary on a new scheme, there is sometimes little difference in the cost. In such cases the greater scope of the high-voltage/low-voltage idea is worth considering, as is also the fact that subsequent additions and extensions to the network can be more readily and cheaply carried out, particularly as this can often be done without changing the existing transformer. On the other hand, it must be pointed out that on such a system the number of transformers is increased and the difficulty of obtaining adequate earths may become more insistent.

It is obvious that the time has come when this problem must be carefully considered in all its aspects. Though the load in towns has by no means reached saturation, the distribution systems are now fairly complete and their development is a matter of strengthening what already exists. The greater increase in load may well come from encouragement of existing small consumers in the use of domestic and other apparatus, thus raising their consumption. New consumers are still obtainable, of course, but this does not mean any great extention of the distribution network. In rural districts, on the other hand, the network itself has to be developed and it would be as well if this took place on as large a scale as possible, in combination with a drive to connect new consumers to the mains.

NOTES.

WORKING HOURS IN MUNITION FACTORIES.

FOLLOWING his intimation of July 17, tha the proposed to bring the Factories Act, limiting the hours of work of women and young persons, again into operation from August 1, Mr. Bevin, the Minister of Labour and National Service, has now issued a circular recommending that the working week for adult male employees should be reduced to 55 or 56 hours. It is pointed out in the circular that during the spurt in production men have been working from 70 to 80 hours a week. It is generally recognised that this procedure cannot profitably be continued for an indefinite period. The Minister however, does not make the mistake of supposing that, in the present emergency, it would be possible immediately to revert to normal hours. He suggests that an interim 60-hours week should be introduced. For convenience in connection with the change-over of shifts, and other matters, the arrangement would consist of a 58-hours week followed by one of 62 hours. Night shifts would run for 10½ hours on five nights a week, with, if necessary, an extra night once a fortnight. It is estimated that, with the shorter week aimed at, it will be possible to put 20 per cent. more workpeople into the factories. The crux of the matter is obviously the supply of this extra 20 per cent. As there is no other supply available, it must consist of unskilled or semi-skilled workers. It is stated in the circular that the Ministry's training scheme is still being expanded and that a rate of output of 400,000 trainees per year is expected to be reached by the end of the year. This, combined with the large supplies which are being made available from the training departments of the factories, should, in due course, provide a supply which may bring the 56-hour week for the majority of skilled workers within the range of possibility. As, however, before that stage is reached, an important minority of semi-skilled workers must reach the stage at which, within restricted fields, they can be trusted with skilled jobs, it may be yet a considerable time before it is attained. If, in the meantime, a general 60-hours week can be arranged for skilled men, the majority will be very satisfied. The Minister has also made an order permitting women and youths over 16 to work on three-shift systems, day-shift systems, day and night shift systems, and day work extending to 60 hours. Special permits are required in connection with these arrangements. In an emergency, a seven-day week may be authorised.

REPAIR OF WAR DAMAGE.

Although, up to the present, this country has not been exposed to mass attack from the air, a certain amount of damage to private property has been suffered. A circular, issued at the beginning of the war, notified the local authorities that stocks of materials suitable for first-aid repairs were being acquired by the Government through H.M. Office of Works. We are now informed that these materials have been allocated to a number of depots throughout the country and will be available for the use of private owners, if they are unable to obtain materials for temporary repairs through the usual suppliers. Applications for these materials should be made to the local housing authority, which, if satisfied of the reasonableness of the request, will pass it on to the local representatives of H.M. Office of Works. Many local authorities have already provided themselves with reserves of materials which can be employed for first-aid repairs to housing accommodation, and experience shows that such repairs have usually been put in hand on the day on which the damage has occurred. This is an important advantage from the psychological point of view, and it is to be hoped that the level of efficiency which it indicates will be maintained. Representations have been made to the Minister that cases may occasionally arise in which ordinary supplies are temporarily exhausted and there is likely to be delay, which would lead to serious loss. Food stores might require immediate protection from the weather or certain repair materials might be necessary to prevent a stoppage at a factory engaged on vital war work. The Minister expresses the hope that if such a case occurs in the area of a housing authority, which possesses the material required, any reasonable request to release such material will be met as a matter of urgent necessity.

THE POSITION OF THE EXPORT TRADE.

The most interesting thing about the statement issued with the monthly trade accounts for June at the beginning of the week is the assurance that the Government still intend to maintain the export trade at the highest level possible. A strong export trade is necessary, of course, in order to pay for munitions and other essential goods, and those engaged on it should realise that they are doing as much towards ultimate victory as others whose contribution is more obvious and direct. There must, however, be limits to the extent to which internal trade can be taxed, and it would be most shortsighted to relax any effort which will increase our manufactures for abroad. Though the returns for June do not make very pleasant reading, there are reasons for supposing that they need not be taken as typical. The value of imports was 90,779,141*l.*, as against 105,552,962*l.* in May, while the total exports amounted to 38,215,027*l.*, against 48,713,588*l.* in the preceding month. This falling off is ascribed to the cessation of the trade with Italy and the invaded countries, while there has been a temporary interruption in the flow of trade from Asia, caused by the diversion of shipping from the Mediterranean. The export figures were also affected by the greater concentration of industry on the production of war materials. On the other hand, exports to the United States and to South America, as well as to Canada, South Africa and Australia, were maintained at the high level of the preceding three months, which shows that recent efforts are bearing fruit.

DEPRECIATION AND THE BUDGET.

Critics of the Budget hold that the new taxation is even now not drastic enough in the light of the need to maintain and increase the nation's war effort, and that the Chancellor of the Exchequer has not shown sufficient initiative in seeking new sources of revenue. Whatever force there may be in this argument, the desirability must be stressed that weaknesses and injustices in the existing financial arrangements should be removed, even if some revenue is lost thereby. One of these, which is especially important to engineers at the present time, was pointed out by Lord Hirst at the recent annual general meeting of the General Electric Company. He felt sure that it had been a wise procedure to set aside a special sum of 100,000*l.* for depreciation, in addition to the sum of 395,000*l.* which had been allocated to meet the normal allowance under that heading. Since the war started, many of the company's factories had been working night and day to provide for the Government's requirements, and latterly the drive had been further intensified to meet the increased seriousness of the position. Clearly, the life of the machinery involved would be shortened and adequate allowance must be made, which he hoped the Government would recognise in assessing the taxation. This was obviously a matter upon which all those concerned should take early steps to make their views clear, since it was evident that the strain on the plant will necessitate replacement at an earlier date than would normally be the case.

FACTORY SITES AND ELECTRICITY SUPPLY.

While the public is prepared to carry heavy financial burdens to hasten the day when hostilities will cease, it is not equally tolerant of waste, especially waste that is caused by carelessness, lack of foresight and inadequate knowledge. The Select Committee on National Expenditure has already done good service by calling attention to numerous derelictions of duty under one or more of these headings, and continues this useful work in its ninth report, which was published last week. Generally speaking, a supply of electricity is a necessity for the efficient operation of a modern factory, yet this fact is sometimes lost sight of by those responsible for selecting the sites for new establishments. The Committee, in fact, "were disturbed to discover that Ministries as a whole seem to attach very little importance to the necessity for closer contact with the electrical industry. They learned from Central Electricity Board witnesses that until recent weeks it was apparently not the responsibility of any Government Department to ensure that new Government factories (or extensions of existing factories) should be so located that electric power from public sources was, or could readily be made, available. They understand that, in some cases, Departments actually acquired factory sites before satisfying themselves that the necessary power was to be had. . . . The siting of new munition factories and the supply of power to all Government concerns should not be settled without previous inquiry of the Central Electricity Board." The suggestion is also made that a small technical advisory committee, consisting of representatives of electrical power producers, and with right of access to the Minister of Transport, should be set up to advise the Board. We hope that this advice will be taken. Mr. Herbert Morrison, at least, knows something about the ramifications of electricity supply.

THE TAX ON KNOWLEDGE.

Generally speaking, the formulation of arguments against the application of the proposed purchase tax to books may be safely left in the hands of Mr. A. P. Herbert, M.P., who may be trusted to deal with them with all the humour and scholarship that has characterised his dual capacities of contributor to *Punch* and Senior Burgess of the University of Oxford. Even he, however, finds some difficulty in distinguishing between one class of book and another and is inclined to regard the continued publication of novels as a necessary means of paying for works of less imaginative content. Not all "serious" books are financial failures; some, indeed, almost deserve to be included among the "best-sellers." We have heard, for instance, that Hall and Knight's *Algebra* provided something like a fortune for its authors, and other examples of the same kind could be adduced. Even were this not the case, there are many books on professional and technical subjects that are as much the tools of those for whom they are compiled as are his pick and shovel to the navvy. Lest it be thought that such a statement of the position is superfluous, we may place on record the statement of Sir George Broadbridge that he "could see nothing to take exception to in the tax on books. Surely book readers could pay something for their hobby." Lord Wolmer was only a little better, for, though he can conceive that books may have their part to play in peace time, apparently he considers that a stop should be placed to their production during war. Engineers of all classes and ages, not to speak of those engaged in other professions, require text books for widening and increasing their knowledge, two operations which are highly essential at the present time. We trust, therefore, that the Chancellor of the Exchequer will change his mind.

SPANISH HANDBOOK ON BRITISH INDUSTRIAL PRACTICE.

The British Standards Institution is engaged on the compilation of a technical handbook in the Spanish language, the object of which is to make known, to prospective purchasers in South America, what British industry has to offer. It will also bring British industrial practice prominently to the attention of importers and inquirers. A committee of direction under the chairmanship of Dr. T. Swinden, set up to examine the project, unanimously decided that the handbook should cover all those branches of industry interested in South American trade. It will be the forerunner of other volumes, dealing in greater detail with individual industries, which will be undertaken at a later date. A supplement to the handbook is being prepared, and this will give British exporters an opportunity of bringing their own particular products to the notice of South American countries. The supplement will be given away with each copy of the handbook sold. The British Standards Institution has circularised trade organisations and export groups likely to be interested, but individual firms who are interested and have not received details regarding the project are invited to communicate with the British Standards Institution, at 28, Victoria-street, London, S.W.1.

HOURS OF WORK IN WAR-TIME.

By H. M. Vernon, M.D.

In these grave times it is essential that our munition workers should achieve the maximum production of which they are capable, and that they should be able to maintain their effort without a break for many months to come. This means that the hours of work imposed on them should not be so excessive as to impair their health. Every worker possesses a capital reserve of physical fitness and energy which can be drawn upon to some extent for a few weeks in times of great emergency, but it must be realised that such a draft on capital inevitably has its after effects. The over-fatigue induced by it lowers working capacity, and a condition of reduced efficiency continues for as long as the over-fatigue exists. The production drive instituted by Lord Beaverbrook and Mr. Herbert Morrison in the latter half of May, when the workers were urged to put in a 12-hour day for seven days a week, caused a considerable rise of production for a very short time, but then it rapidly fell back and, judging by the light of previous experience, it is probable that, so long as the excessive hours of labour are maintained, the individual output of many of the workers is less than before the drive was initiated. The need for a reduction in the hours very soon became evident to the Government authorities, and as early as May 29, Mr. Bevin pointed out that "rest periods there must be, for health and efficiency demand them." A fortnight later the Factory and Welfare Advisory Board appointed by Mr. Bevin recommended that there should be frequent rest periods, and that a weekly day of rest (not necessarily Sunday) should be restored at the earliest possible date. The introduction of periodical rests for workers must not be taken to imply that the plant will be kept idle, for Mr. Bevin is working out a system of relays, or hours-on rotation, which will be circulated to all managements in the country.

The allowance of one free day a week may, therefore, be taken to meet with general acceptance, but we have still to try and decide upon the hours which should be worked on the remaining six days. It is best to consider first the hours most suitable for women, for they are much more sensitive to excessive hours than men, and quickly deteriorate in health and efficiency.

Hours of Work for Women.—The hours for which women are allowed to work under the Factories Act, 1937, are normally 48 per week, with provision for 6 hours a week of overtime for a total period of 25 weeks a year, but the Home Secretary has powers to increase the hours of overtime employment allowed in any week or for any number of weeks if he is satisfied that the increase is necessary "owing to the exigencies of the trade carried on" or "by reason of unforeseen pressure of work due to sudden orders." He therefore has complete freedom to fix any hours he likes, but during the first eight months of the war the 54-hour week was not greatly exceeded. At first, a maximum of 60 hours a week was provisionally authorised, but formal orders were soon made reducing the maximum to 57 hours a week. Later on, many of the factory occupiers, when applying for a renewal of the original order, proposed a reduction of the working week to 54 hours or even less, and, consequently, complied with the ordinary provisions of the Act. However, the advent of the production drive in May caused these reasonable hours to be completely ignored, so much so that Mr. Bevin quickly became very concerned about the effects of the excessive hours on the health of the women and young persons involved. He decreed that the Factory Acts should be brought back into full use on August 1, but we have no way of knowing what this means in actual practice. As is pointed out in *The Times* (July 19), "The requirements of the statute have been modified by Home Office Orders so as to meet the necessities of war-time pressure for rapid production. When the operation of the Factory Act is re-enforced these Orders will not be abrogated." This statement must not be taken to imply that the excessive hours of work imposed during the last war are likely to be copied. In fact, *The Times* forcefully declares that "No industrial lesson was more clear in the last war than that an over-long working week decreases output."

We are still left in the dark as to the optimum length of the working week for women in war-time, so we are driven to try and ascertain it in the light of previous experience. If we relied on the large volume of evidence obtained under peace-time conditions in various industries, we could safely conclude that a 48-hour week was long enough. For instance, Messrs. Mather and Platt found that at a factory engaged in general engineering work (the Salford Iron Works), a week of 48 hours gave a slightly better output, both in regard to time-workers and piece-workers, than a 53-hour week. As a direct consequence of this result, various Government factories engaged in the production of ordnance, army clothing, small arms inspection, etc., reduced hours from 54 to 48 a week, with an equally satisfactory outcome. Further evidence in favour of a working week of 48 hours or less has been obtained in other countries.

It does not follow that munition workers, employed in time of war, will be unable to achieve better results than peace-time workers, and one of the arguments most frequently used in support of long hours of work during the last war was that patriotism introduced a new incentive which rendered all previous experience unreliable. Undoubtedly, there is some weight in this argument, but what does it amount to? The only means to test its validity is to collect statistical evidence at munition factories where various lengths of working week have been tried. The Health of Munition Workers Committee, appointed in 1915 by Mr. Lloyd George, to consider and advise on questions of hours of labour and other matters affecting the health and efficiency of the workers, instituted statistical investigations on output in a number of factories producing various kinds of munitions. A fuse factory was found to offer the best opportunities, for there the hours of work were at first about 74½ a week (*i.e.*, a 12-hr. day with Sunday labour), but were subsequently reduced to 63½ hours (a 10-hr. day with Sunday labour), and then to 55 hours (a 10-hr. day without Sunday labour). The output of typical groups of the men and women working under these three sets of conditions was ascertained week by week for a period of one to two years, and a few of the numerical data obtained may be quoted here. A group of 100 to 80 experienced women employed in turning aluminium fuse bodies on capstan lathes gave the following average results:

Weekly Hours of Work Fixed by the Management.	Hours for which the Workers were Present in the Factory.	Output of Fuse Bodies per Week (as Percentages).
74·5	66·0	100
63·5	54·4	100
55·3	47·5	113

It will be seen that the 10-hour day, without Sunday labour, yielded the best production, though the hours of work were then 18½ less per week than at first. It will be noted that the timekeeping was bad, and that even during the 55-hour week the women put in only 47½ hours of actual work. There can be no doubt that if the nominal hours of work had been fixed at 54 a week, or even less, they would still have been able to put in an attendance for 47½ hours, and so keep up their output.

The women turning the fuse bodies could to some extent quicken up their speed of work throughout the complex operation required of them, but another group of women, who were milling a screw thread on the fuse bodies, were more limited by their machines. Yet even they attained the same output when on a 57-hour week as on a 72-hour week. They put in only 48·1 hours of actual work under the former conditions, so it is evident that they too could have achieved just as good a production if they had been on a working week of 54 hours or less.

The reason why these and other munition women kept such bad time was not in any way due to slackness. It was because they found it necessary to take a day off work every week or fortnight in order to recuperate from their fatigue, and be able to struggle on. As it was, the labour wastage of most of the groups studied was very considerable. In every three-month period about a third of them dropped out altogether, largely from ill-health, while a medical examination of 2,500 women working at various munition factories, showed that more than a third were suffering from "some fatigue or ill-health," while 7 per cent. were in a condition of "marked fatigue or ill-health." Of the women who dropped out altogether, a number died, especially from phthisis. The young women, aged 15 to 24, were specially affected, and for this and other reasons it is to be hoped that Mr. Bevin and his advisers will be very cautious in allowing young persons, that is, those under 18) to work for longer than the normal hours permitted by the Factories Act.

The evidence adduced, and other evidence for which there is no space, strongly suggests that the working week for women should not be more than 54 hours, and that a somewhat shorter week might yield as good an output.

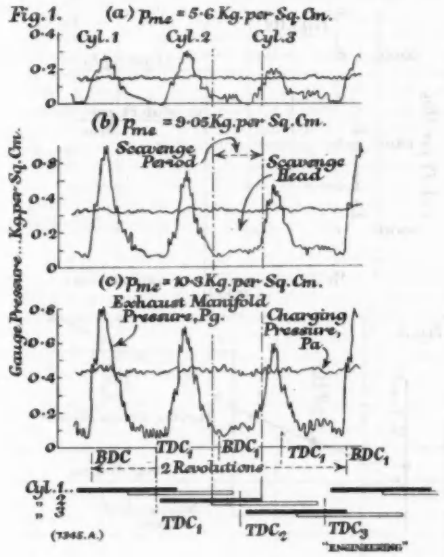
Hours of Work for Men.—The Health of Munition Workers Committee at first recommended that for men the average weekly hours of employment should not exceed 65 to 67, exclusive of meals, but after statistical evidence had been collected they modified their views considerably. They stated that they were "convinced that the maximum limits of weekly employment provisionally suggested are too high except for quite short periods," and they were satisfied that in the great majority of cases "reductions can be made with benefit to health and without injury to output."

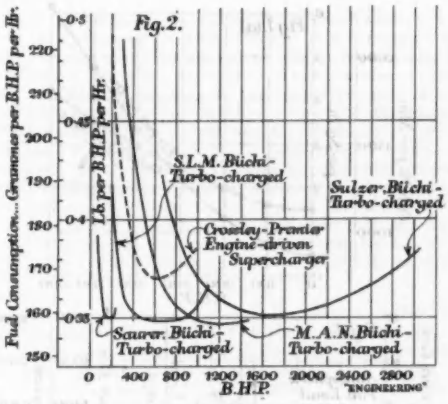
A medical examination of 1,500 men in 1916 showed that 31 per cent. of them were working 60 hours to 70 hours a week, and 37 per cent. from 70 hours to 100 hours, but in spite of these very long hours their health was fairly good. Only in 5 per cent. of the men were health and physical condition found to be "much below normal," while in 0·4 per cent. of them health was definitely "bad." It might, therefore, be maintained that the very long hours imposed resulted in a better output than shorter hours would have done, but the evidence is against such a view. The investigations made at the fuse factory showed that men employed on the rather heavy work of sizing fuse bodies attained a considerably greater output on a 55-hour week than on a 67-hour week. However, it should be mentioned that a group of youths employed on the operation of boring top caps attained 7 per cent. less output in a 60-hour week than in one of 76½ hours, but this was because they were greatly limited by their machines.

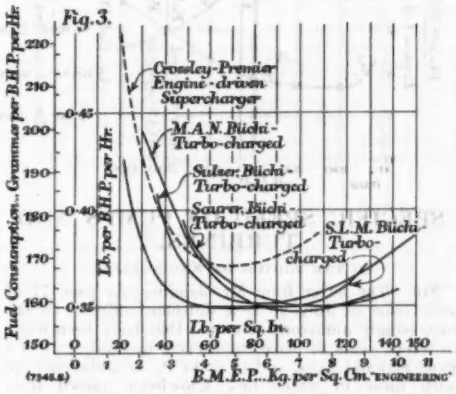
It may be thought that men such as tool setters, whose occupation is fairly light in the physical sense, can work efficiently for long hours, but this is very doubtful. Evidence bearing on the question was obtained at a factory devoted to the production of 9·2-in. shells. Here the men were on a two-shift system and averaged 63 hours a week, while the women were on a three-shift system and averaged 44 hours. When both men and women were changed to a two-shift system averaging 54 hours, the hourly rate of production rose very substantially in all the four shell operations investigated. Though the women must have experienced greater fatigue than before, this was more than balanced by the lessened fatigue of the men (tool setters and labourers) on whom they depended.

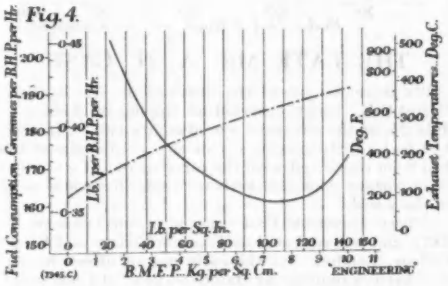
Directory of British Fine Chemicals.—A new list, dated April, 1940, of fine chemicals manufactured in Great Britain has recently been issued by the Association of British Chemical Manufacturers, 166, Piccadilly, London, W.1. The list, which is intended for research chemists and other users of fine chemicals, covers the products of 61 manufacturing firms, the products being arranged in alphabetical order and each entry being followed by a number, or numbers, indicating the manufacturer's name. We are informed that this very useful publication will be supplied gratis to *bona fide* users of fine chemicals on application to the Association at the address given above.

FIFTY YEARS OF PRESSURE SCAVENGING.









LETTERS TO THE EDITOR.

FIFTY YEARS OF PRESSURE SCAVENGING.

TO THE EDITOR OF ENGINEERING.

SIR,—In the article by Mr. W. A. Tookey, published in your issue of June 21, entitled "Fifty Years of Pressure-Scavenging," certain statements were made which I feel should not be allowed to pass unchallenged. Before passing on to a technical analysis of this article, I would like to voice a regret, which other readers will, undoubtedly, also have felt, that Mr. Tookey has thought fit to stress repeatedly the British and Continental origins of the systems under review. It is, and always has been, a characteristic of our profession to rise above the limitations of international boundaries, and such eminent engineers as Rateau and Büchi are as highly honoured in this country as in their own lands.

The description of the Hamilton system of pressure-scavenging is interesting and important—important, because it stresses so clearly the advantages of scavenge. This, Büchi has also realised, and, if one follows the development of turbo-charging, it will be seen that it has always led towards an increased scavenge effect. To-day, for example, the valve overlap is generally 140 deg. to 150 deg., and the air quantity for scavenge is of the order of 35 per cent. of the cylinder volume. An interesting point here is that this scavenge air, which picks up heat and residual gas in the cylinder, is available for doing work in the turbine, whereas with the so-called Hamilton system practically the entire energy in the scavenge air is lost. This point has not been mentioned by Mr. Tookey, but it is important as it limits the degree of scavenge economically permissible with a system using belt-, gear- or motor-driven blowers. In describing the application of the Hamilton system to the heavy oil engine, he refers to it as a means of meeting an "occasional demand for boost outputs" with the operator switching the booster in and out as the load requires. The turbo-charger used in the Büchi system is, however, not an occasional booster, but is an integral part of the engine cycle, designed so as to benefit the engine over the whole working range. The scavenge effect and weight of air supplied to the cylinders follow the load automatically, giving a flexible system allowing heavy overloads to be carried while at the same time improving conditions over the lower load range.

An engine fitted with an independently-driven blower may be at some advantage in point of reliability as the removal of the blower is possible without shutting down the engine. This is usually not the case with the turbo-charger, as the provision of an exhaust by-pass has long since been discontinued. Contrary to Mr. Tookey's statements, however, a breakdown of the turbo-charger does not necessarily entail stoppage of the engine, which can operate up to its normal straight rating with the turbo-charger in position but out of service, *i.e.*, with the turbine rotor blocked.

With regard to quick response, it is essential to note, in the first place, that when the engine is idling, the turbo-charger is still running at about 30 per cent. to 45 per cent. of normal full speed and supplying a quantity of air sufficient to permit the engine to carry at least 75 per cent. of the full pressure-charged rating. Secondly, tests have established the fact that it requires only about 10 seconds for a turbo-charger, such as would be fitted to a 1,000-h.p. engine, to attain normal speed when full load is suddenly applied, and actually after 5 seconds, or less, the blower is already supplying the minimum quantity of air required for complete combustion of the full-load fuel quantity. Turbo-charged engines are being widely used for traction and marine purposes, and this in itself is sufficient proof that this system is not detrimental to flexibility.

Among some of the loose statements made by Mr. Tookey, we read, for example, the following:—"An exhaust-pressure driven turbo blower, *ipso facto*, implies the existence of gas pressure within an engine cylinder, resistant to the motion of the piston during its exhaust stroke. This entails the proportionate augmentation of the fuel taking part in combustion to overcome the additional pumping loss. Not only so, but the mean resistant exhaust pressure prevails until the air-inlet valve is opened." When the exhaust valve opens, the pressure in the cylinder is of the order of 50 lb. to 60 lb. per square inch, and this represents a high potential energy, which is made use of in the Büchi system without measurably increasing the effective back pressure on the engine, because, contrary to Mr. Tookey's statement, the mean resistant exhaust pressure does not prevail until the air-inlet valve opens. This is well illustrated by Fig. 1, which is an oscillographic record of the exhaust-manifold pressure taken at various loads on a six-cylinder turbo-charged engine. This diagram also makes it clear that during the scavenge period the pressure in the exhaust manifold has dropped to a point only slightly above the atmosphere even when the engine is operating at a b.m.e.p. of 146 lb. per square inch (10·3 kg. per square centimetre). In consequence, contrary to Mr. Tookey's contention, no appreciable augmentation in the charging pressure is required in order to effect complete scavenge. This is also substantiated by the figures given in Table II of the article in question, which indicate that, for the same b.m.e.p., the exhaust turbo-charged engine actually requires a lower induction pressure, *i.e.*, scavenge pressure, than does the Hamilton system.

In comparing engine performance, no temperatures or heat balance are given, and Mr. Tookey has taken as basis for comparative fuel consumption a turbo-charged engine which he tested nine years ago and which was put into service in the previous year; technically, this engine must now be considered as obsolete. In passing, it may be of interest to quote an extract from the conclusions embodied in his official report on these tests:—"During the trials the limit of power output was demonstrated as being due to the maximum fuel-pump capacity having been reached. In my opinion, higher brake mean effective pressures could have been produced with safety and economy had it been possible to increase the amount of fuel injected at each cycle. The maximum output actually attained (1,330 brake horse-power) was no less than 56·5 per cent. above the normal unsupercharged rating (850 brake horse-power). It is a remarkable feature of this series of tests that the extremely low rate of fuel-oil consumption extends—with practically no variation—from 750 brake horse-power to the 1,330 brake horse-power which, for the reason already stated, was the highest output possible under the conditions obtaining. This is not only a testimony to good design, but to excellent workmanship. It will be noted that repeated tests at similar loads at different periods gave uniform results, and this with entire absence of hand adjustment or 'nursing.'"

A fairer comparison could have been made by taking any of the many recently published performance figures for turbo-charged engines. For example, in the July, 1938, number of *The Oil Engine*, the very same fan pressure-charged engine was compared with the performance of a number of Continental turbo-charged units and performance figures were also given for a modern Ruston turbo-charged engine, six-cylinder, 10¼-in. bore, 14½-in. stroke, rated at 550 brake horse-power at 500 r.p.m. These performance curves are reproduced here in Figs. 2, 3 and 4. Other equally good fuel-consumption figures of turbo-charged engines have been given, for example, in the March and April numbers of *The Oil Engine* and *Gas and Oil Power*.

In the last analysis, however, it is the extent of the application of a particular system which is the true criterion. Mr. Tookey mentions a figure of 110,000 h.p. for the aggregate output for engines embodying the modified Hamilton system, whereas the engines operating with the Büchi system of turbo-charging have a total horse-power of well over ten times that figure.

Yours faithfully,

E. S. DEAN.

56, Victoria-street, London, S.W.1.
July 8, 1940.

TO THE EDITOR OF ENGINEERING.

SIR,—In Mr. Tookey's article, published in your issue of June 21, on page 595, the comparisons he makes between mechanically-driven and turbine-driven superchargers are interesting, but I feel there are a number of points which he has overlooked. In the first place, if comparison is to be made on the basis of fuel consumption, it is essential that engines of identical combustion characteristics should be used for the experiment. That is to say, comparison should be made between the same engine (or, at least, identical engines) fitted, on the one hand, with a turbo-charger, and on the other with a mechanically-driven blower.

(1) Fan-Pressure Charged.		(2) Turbo Charged.		(3) Turbo Charged.	
B.M.E.P. Lb. per sq. in.	Lb. per B.H.P. per hr.	B.M.E.P. Lb. per sq. in.	Lb. per B.H.P. per hr.	B.M.E.P. Lb. per sq. in.	Lb. per B.H.P. per hr.
45·0	0·385	51·0	0·391	51·0	0·385
71·0	0·370	60·5	0·388	60·5	0·370
93·3	0·374	75·0	0·377	75·0	0·363
106·8	0·386	82·5	0·378	82·5	0·364
		96·0	0·376	96·0	0·368
		109·0	0·376	109·0	0·375
				115·0	0·376

Other comparisons are meaningless, as the accompanying table will show. Columns 1 and 2 are taken from Table II of Mr. Tookey's article, and column 3 gives figures for an eight-cylinder 16 in. × 21½ in. engine running at 300 r.p.m. These figures prove nothing except that it is possible to obtain better fuel consumptions with one type of turbo-charged engine (No. 3) than with another type of turbo-charged engine (No. 2) or a third and different type of engine with mechanically-driven pressure charger. Mr.

Tookey's Table II is useless as a basis for comparison unless the two engines reported on are identical.

Considering now the question of the power lost in the blower. The curves in Fig. 1 (*a*) show the free volume and pressure of charging air delivered by the exhaust turbo-charger of an engine normally rated at 330 brake horse-power and supercharged up to 500 h.p. The engine is 11 in. × 15 in., and runs at 428 r.p.m. From this curve, figures of horse-power have been estimated by reference to a blower-manufacturer's published tables (it should be noted that the figures do not refer to the horse-power actually absorbed by the turbine, but to the horse-power that would have been absorbed by a high-efficiency blower). These are shown in curve A, Fig. 2, expressed as a percentage of the engine indicated horse-power. Fig. 1 (*b*) shows the volume of air consumed by the same engine if supercharged for the same output on the system described by Mr. Tookey, the blower being switched on at 300 brake horse-power. Curve B in Fig. 2, shows the horse-power that would be absorbed in this case, expressed also as a percentage of the engine indicated horse-power.

Mr. Tookey has overlooked one of the most valuable features of the exhaust turbo-driven blower—the fact that the weight of air delivered varies with the weight of fuel consumed. Fig. 3 brings out this characteristic very clearly, the volume of air at inlet conditions being plotted against fuel per hour for the two systems of supercharging. The constant slope (between 75 lb. per hour and 200 lb. per hour) of the curve relating to the turbo-charged engine is worthy of note. This variable-output characteristic of the blower is, of course, extremely valuable for variable-speed engines, as the blower output follows not only the speed of the engine, but also the load on the engine.

With regard to the indicator cards shown by Mr. Tookey, it is a pity that no scale was attached to the light-spring cards. Had this been done, it would have been possible to plot the power absorbed by the mechanically-driven blower, expressed as lb. per sq. in. of engine piston. Without this the cards prove nothing, for the loss in m.e.p. clearly indicated in Fig. 8, compared with Fig. 9, may quite well be either (*a*) compensated for by the loss in b.m.e.p. due to the fan, or (*b*) outweighed by a higher m.e.p. of card 8 as a whole. In internal-combustion engineering, of all things, "casual glances" are most unwise.

When considering the exhaust turbo-charged engine, it is not sufficient to examine exhaust phenomena at the exhaust valve. The cycle is not complete until the waste gases leave the turbine. The exhaust turbo-charged engine may be regarded as an engine in which both compression and expansion are carried out in two stages. Mr. Tookey is, in effect, comparing the phenomena at the end of expansion of a single-stage machine with those at the end of expansion of the first stage of a two-stage machine. This may be interesting, but can give no indication of the relative efficiency.

There are many other points in Mr. Tookey's article that could well be taken up. For example, he suggests that the exhaust turbo-charged engine is less flexible in the face of sudden changes of load. Actually, the reverse is the case. There is so little friction in the blower that it actually takes 15 minutes to come to rest from full speed, and it is so sensitive to changes in exhaust energy that, on a 1,000-h.p. engine, the momentary speed drop, when full load is thrown on to the engine from no load, is only 2 per cent. As this load represents 50 per cent. overload on the atmospheric rating, it is evident that the blower loses no time in supplying the necessary air. One hesitates to ask Mr. Tookey what his reactions would be if he were "standing by" a "Hamilton-charged" engine on no load, with the blower stopped, when some unfeeling electrical consumer presented the engine with 50 per cent. over atmospheric full load!

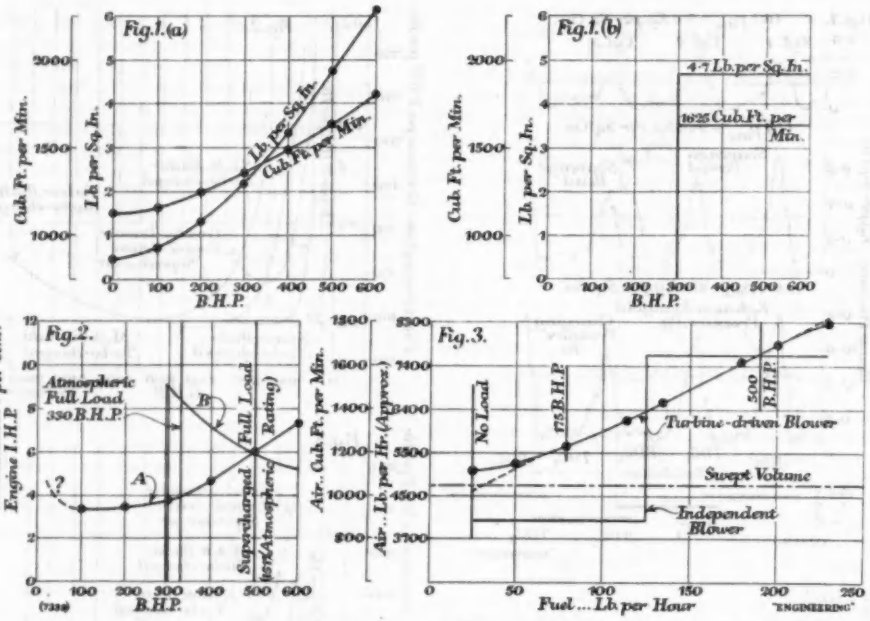
One final point. It is evident that in any given case, either the mechanically-driven, or the exhaust turbine-driven blower, will have technical advantages over the other. The system to be used should be chosen on these technical merits, all other things being equal. Mr. Tookey may decry engineers for using what he calls "Continental" systems. I beg to suggest, however, that there is no such thing as a "Continental" system of supercharging, any more than there is a "British" system. The engineers art is an international art, and should take no notice of arbitrary political boundaries, which recent events have proved to be extremely fragile in any case. When discussing the technical merits of any engineering work, it seems to me that the place of origin is irrelevant. This insularity is out of date in these times, and I suggest that the more we open our minds to ideas from engineers abroad, the more we shall learn and the better it will be for engineering as a whole.

Yours faithfully,

T. D. Walshaw, B.Sc.(Eng.),
D.L.C.Hons.

140, Withington Road, Manchester, 16.
July 8, 1940.

FIFTY YEARS OF PRESSURE SCAVENGING.



SPECIFIC SPEED OF PUMPS AND TURBINES.

To the Editor of Engineering.

Sir,—The letter from Mr. Jennings on page 77 of your issue of July 26 is a welcome addition to the increasingly numerous attempts that have been made in recent years to place engineering hydraulics upon a more rational basis, and to make its formulæ conform with those in which new knowledge gained from experimental aero- and hydro-dynamics is commonly presented. In this connection the use of the relations between non-dimensional groups of the relevant factors, as a means of expressing characteristic behaviour, is a notable feature, offering the advantages of compactness, simplicity and precise physical meaning. It is because Mr. Jenning's analysis does not appear fully to exploit these possibilities that the following suggestions are made: By analogy with such well-established terms as specific gravity and specific heat, the word "specific" used in conjunction with speed implies a numerical ratio and must, therefore, as Mr. Jennings observes, be non-dimensional. With equal force, however, "specific speed" implies here a ratio between two rates of rotation, just as specific gravity is the ratio between two densities and specific heat the ratio between two thermal capacities. Hence, it seems more logical for the ratio n_s/n (which at sight is obviously non-dimensional) to be related to another non-dimensional group,* rather than for n_s alone to be regarded as a mere number, as Mr. Jennings has done, and equated to a non-dimensional group including n. In the former case, n_s has the dimension 1/time and the "specific" (or, preferably, "characteristic") speed may be expressed in Mr. Jenning's notation by :—

$$n_s = \frac{n\,p}{\rho g h q} = \frac{n\,p}{w h q}$$

where w is the density of the fluid in units of weight/volume. This formula is applicable both to turbines and pumps, and has the merit of being simpler than either of the separate expressions found by Mr. Jennings. Indeed, the impossibility of assigning a physical concept to symbols like $P^{\frac{1}{2}}$ or $H^{\frac{5}{4}}$ is not least among the difficulties inherent in the usual expressions for specific speed.

It is unfortunate that non-dimensional expression does not obviate changes of numerical value according to the system of units employed, even though the units within any one system are consistent among themselves. It should not, however, be necessary to consider more than one British and one metric system, flow-rate in the latter being, for consistency, measured in cubic metres per second. The fact that Mr. Jennings has deemed it desirable to compute separate conversion factors for systems involving Imperial gallons and United States gallons provides an opportunity for urging that hydraulic and ventilating engineers should agree to think of quantity in terms of cubic feet.

Yours faithfully,

F. C. Johansen.

L.M.S. Railway Research Department, Derby.
July 29, 1940.

* Cf. Lea's *Hydraulics*, 5th. ed., pages 534 and 758.

THE LATE MR. A. H. CASE.

We regret to record the death of Mr. A. H. Case, M.Inst.C.E., which occurred at Epping on Thursday, July 25, at the advanced age of eighty-two. Mr. Case had had a distinguished career as a civil engineer and had been connected with the carrying out of a number of important dock and harbour works in various parts of the world.

Albert Havelock Case was born on October 14, 1857, and was educated at Taunton College and King's College, London. At the early age of fifteen he was articled as a pupil to Mr. James Sargent, of Trowbridge, where he occupied various positions in the shops and subsequently served for two years in the drawing office of Messrs. Stothert and Pitt, Limited, Bath, and for about a year with the French State Railways, at Tours. He then obtained a position on the staff of Sir John Coode, M.Inst.C.E., under whom he was engaged as resident engineer on surveys for, and superintending the construction of, foreshore protection work at Spurn Point and Hastings, and reclamation work on the estuary at Duddon, Cumberland. In 1891 he joined the staff of Sir John Wolfe Barry and acted under him as resident engineer on the construction of the deep-water entrance at the Tyne Docks and on similar work on the deep-water lock and graving dock at the Barry Dock. After being employed as resident engineer for Messrs. Meik and Foster Brown on the construction of the Port Talbot dock and railways, he became engineer-in-chief to the Port Talbot Railway and Dock Company on the completion of the works. In 1899, however, he entered the service of Trinity House and was engaged under them in the construction of the Beachy Head lighthouse.

On the completion of the last-mentioned work, in 1904, Mr. Case commenced private practice as a consulting engineer, being subsequently joined by Dr. Bryson Cunningham. Among the works he carried out while so engaged was the preparation of informative reports on the harbour works at Montevideo, Nassau in the Bahamas, and Malta, and on the shipping facilities at Villaricos on the Mediterranean coast of Spain. Some of this work was carried out at the request of Lloyds, while, in 1911-12, at the request of Sir William Matthews, he visited the River Plate and reported on Montevideo Harbour. From 1916 to 1919 he was consulting engineer to the Lower Ouse Drainage Board, and prepared schemes for the proposed improvements of the river between Denver sluices and King's Lynn, with outfall training walls in the Wash. After the Great War he was appointed by the Board of Trade to visit Petrograd Harbour and Cronstadt Harbour and report upon their condition, this work being undertaken at the request of the Russian Government.

Mr. Case, who gained a Whitworth Scholarship in 1883, was elected an associate-member of the Institution of Civil Engineers in 1884 and was transferred to the class of member in 1893. In 1905 he contributed a paper on "Beachy Head New Lighthouse," for which he was awarded a Miller Prize. He was also a member of the Association of Consulting Engineers.

LABOUR NOTES.

The Ministry of Labour Gazette states that, in the industries for which statistics are regularly compiled by the Ministry of Labour and National Service, the changes in rates of wages reported to have come into operation in June are estimated to have resulted in an increase of about 215,000*l.* in the weekly full-time wages of about 2,160,000 workpeople and in a decrease of 600*l.* in those of 90,000 workpeople. The workpeople whose wages were reduced had received increases of greater amount in earlier months of the year. The changes so far reported in the six completed months of 1940 in the industries for which statistics are available are estimated to have resulted in a net increase of over 1,400,000*l.* in the weekly full-time wages of about 6,600,000 workpeople.

The principal groups of workpeople whose wages were increased in June included coal miners in Northumberland, Durham, Yorkshire, Nottinghamshire, Derbyshire, Leicestershire, Warwickshire and Cannock Chase; workers employed in pig iron and iron and steel manufacture in various districts, building trade operatives in England and Wales and in Northern Ireland, railway employees, paper box and paper bag makers, laundry workers, bakers in Scotland, tobacco workers, and gas workers. The 90,000 workpeople whose rates of wages were reduced were coal miners in Scotland.

It is officially reckoned that the number of insured persons between the ages of 16 and 64, recorded as unemployed in Great Britain and Northern Ireland at June 17, 1940, represented 5·2 per cent. of the total number of insured persons between the ages of 16 and 64 at July, 1939, as compared with 6·1 per cent. at May 20, 1940. At June 12, 1939, the corresponding percentage was 9·3. For persons insured under the general scheme, the percentages were 5·3 at June 17, 1940, as compared with 6·2 at May 20, 1940, and 9·6 at June 12, 1939. For persons within the agricultural scheme, the percentages were 2·3, 3·4 and 4·3, respectively.

At June 17, there were 648,314 persons on the registers of Employment Exchanges in Great Britain who were out of a situation. This was 82,459 less than at May 20, 1940, and 450,479 less than at June 12, 1939. There were registered as unemployed in Great Britain 81,380 persons who were on short time or otherwise temporarily suspended from work. This was 21,350 less than at May 20, 1940, and 114,245 less than at June 12, 1939. Of workers who normally seek a livelihood by means of jobs of short duration, there were on the registers in Great Britain 37,141 unemployed persons. This was 10,178 less than at May 20, 1940, and 18,020 less than at June 12, 1939. The total of 766,835 persons on the registers at June 17, 1940, included 605,121 applicants for unemployed benefit or allowances.

The number of trade disputes involving stoppages of work, reported to the Ministry of Labour and National Service as beginning in June, was 30. In addition, four disputes which began before June were still in progress at the beginning of that month. The appropriate number of workpeople involved in these 35 disputes, including workpeople thrown out of work at the establishments where the disputes occurred, was about 7,000, and the aggregate duration of the disputes in June was about 14,000 working days. These figures are the lowest for any month since September, 1934.

A national joint industrial council has been set up for the omnibus industry—excluding municipal undertakings and the London Passenger Transport Board. On the employers' side it is representative of companies in England and Wales owning 100 omnibuses or more, and on the workers' side by the Transport and General Workers' Union, the National Union of Railwaymen and the National Union of General and Municipal Workers. The constitution of the council provides machinery for the prevention and settlement of differences in connection with the terms and conditions of employment of certain grades and classes of persons concerned with the operation of public-service vehicles.

Modified arrangements have been made for the payment of fares and travelling allowances to workers who are transferred by the Ministry of Labour and National Service to undertake work of national importance in an area beyond daily travelling distance from their homes. In such cases, the Department will pay the fare for the initial journey to the place of work to which the worker is transferred, and will also pay 5*s.* travelling time for the initial journey if this does not occupy more than four hours, or 10*s.* if the journey occupies more than four hours. This arrangement supersedes the original proposal that employers should be called upon to pay for fares and travelling time for transferred workers. No payments will be made by the Ministry of Labour and National Service in respect of daily travelling to and from work.

The scheme will not apply in cases where a worker is transferred to work where it is the practice, either by custom or by agreement, for such payments to be made by the employer. Where, under customary practice or agreement, the employer pays fares but does not pay for travelling time, the allowances for travelling time will be payable by the Ministry as set out above. Further, the scheme does not apply in any way to the transfer of dockers or to the transfer of building and civil engineering workers. Special arrangements have been made to meet the needs of those industries. Employers and workers affected by this arrangement may obtain further information at local offices of the Ministry of Labour and National Service.

In addition to its three permanent members, whose names were announced recently, the new National Arbitration Tribunal is to include a representative of the employers and a representative of labour. The General Council of the Trades Union Congress has formed the following panel from which its representative will be chosen:—Mr. J. W. Bowen (ex-general secretary of the Union of Post Office Workers), Mr. W. J. Farthing (Transport and General Workers' Union), Mr. Luke Fawcett (Building Trade Workers), Mr. Mark Hodgson (Boilermakers' Society), Mr. James Kaylor (Amalgamated Engineering Union), Mr. John Stokes (London Glass Bottle Makers), Mr. Alfred M. Wall (London Society of Compositors), and Miss Madeline Symons (General and Municipal Workers' Union).

The General Council of the Trades Union Congress has been informed by the Ministry of Labour and National Service that an Order is shortly to be made requiring the occupier of any named factory to make arrangements for part or whole-time doctors, nurses, and officers to supervise the welfare of persons employed. The council welcomed the proposal as the beginning of a factory medical and welfare service, which might be extended, the council thinks, so as to establish the principle of a State medical service.

Local trades councils are to be invited to nominate representatives to serve on bodies in each area which will see all men who have been wholly unemployed for more than a month. The main purpose is to ascertain the industrial possibilities of the long unemployed and to recommend them, when suitable, for transference to other employment, to full-time civil defence or other national service or for a training course. It has been agreed, the General Council announces, that the consent of the men concerned must be obtained before they are sent to any kind of national service or for training. Similar inquiries for the coal-mining, engineering and shipbuilding industries are already in progress.

Speaking at the National Trade Union Club in London last week, Mr. Herbert Morrison, the Minister of Supply, said that he was profoundly grateful for the unsparing efforts that the workers had made. But the speed-up in its most intense form was necessarily a short-term measure; neither in the interests of the workers themselves nor in the interests of maximum output could a week of seven days be worked indefinitely. In the Royal Ordnance factories gradual reduction in working hours had been arranged according to the circumstances and the type of work, and he hoped that similar modifications would extend throughout all the 1,500 private factories working under the control of the Government. Among other measures being taken to increase the productive capacity of the country for war purposes was the setting up of a new area organisation to assist in ensuring that all plant capable of serving our war needs was used. The reconstituted area boards would include in their membership representatives of organised labour and of industrialists. That meant that the trade unions and the management side in industry would no longer act in an advisory capacity only, but would sit in the seats of decision.

Answering a question in the House of Commons last week, Mr. Bevin, the Minister of Labour and National Service, said that he had no statistics showing the extent of absenteeism in munition factories since the introduction of weekend and other forms of overtime working. It was evident, however, he added, that undue exhaustion was one of the causes of absenteeism which must be prevented if production was to be maintained at a maximum. To secure that, he was issuing immediately some notes for guidance on hours of work and maximum production.

THE FUTURE OF BRITISH CIVIL AVIATION.

THE twenty-eighth Wilbur Wright Memorial Lecture of the Royal Aeronautical Society was delivered on May 30 by Dr. H. Roxbee Cox, the Chief Technical Officer of the Air Registration Board. The lecture, which is entitled "Looking Forward: Prolegomena for a Detailed Study of the Future of British Civil Aviation," is, in its printed form, of great length, running to no less than 73 pages, and it would not be possible to give a proper idea of its contents by abstracting it in the usual way and printing only selected passages. Accordingly, that which follows is a summary rather than an abstract, although, where possible, Dr. Cox's text has been adhered to.

Introduction.—In the stress of war, civil aviation must not be forgotten. When a country is fighting for its life, its primary object is to win. That, however, is not our sole aim. It is generally agreed that we are fighting, too, for our civilisation. It would seem axiomatic, then, that we must preserve the means of civilisation, of which civil aviation is one. British civil aviation at the outbreak of war was at the beginning of a struggle to make for itself a position in world aviation worthy of the Empire. Unless the struggle is sustained, we shall find at the end of the war that our position in relation to our greatest rivals is desperately, if not irretrievably, inferior. Plans would have been made for the furthering of British civil aviation had the war not happened, and plans—more modest plans, perhaps—must still be made. In other fields great efforts are being made that our instruments of commerce and communication may remain unimpaired. It is my conviction that our air communications also should proceed as closely as may be possible along the lines of their peace-time development. Because any discussion of the future must be related to the background of the past, I begin with a note on the recent trend of opinion. This leads to an attempt to define our aims and a review of what has to be done to achieve them. On the assumption that the programme indicated cannot now be attempted, the paper concludes with a modest substitute programme appropriate to war conditions.

The Immediate Past.—The story of British civil aviation in the years preceding the outbreak of hostilities is punctuated by reports of committees set up by the Government. The more important recommendations of these committees were accepted by the Government and in large measure defined the basis on which the future was to be built. The first—the Gorell Committee—was formed in July, 1933, primarily to examine the system of control of private flying. At that time the control of civil aviation in all its aspects lay with the Air Ministry. The Society of British Aircraft Constructors represented to the committee that the control of design and construction was restrictive, increased cost and retarded commercial development, and that, without the good relations existing between Air Ministry officials and firms, aircraft construction would become almost impossible. The committee felt that there was substance in this charge, although appreciating that the Air Ministry had moved in the direction of devolution by admitting representatives of the industry to the Civil Airworthiness Committee and delegating a large measure of responsibility to many constructors for the design and inspection of their own aircraft. They recommended that the control of the airworthiness of civil aircraft should be devolved from the Air Ministry to a statutory autonomous and executive authority, composed of representatives of the manufacturers, operators and undertakers, to be called the Air Registration Board. The Air Council accepted this recommendation in principle, but it was considered that the Air Ministry should retain control over the airworthiness of the larger passenger aircraft.

The acceptance, although with reservations, of this recommendation is a landmark in British civil aviation. A system which, in all essentials, still controls the most successful civil aviation industry in the world, that of the United States, had failed to flourish in this more temperate climate and was replaced by a system in which the aircraft industry had a direct concern in its own government. The Air Registration Board began operations on April 1, 1937, and by the beginning of the war had assumed responsibility for the formulation of technical requirements and examination of new types of civil aircraft, survey, inspection, etc. The limitation of the size of aircraft supervised by the Board was fixed at 10,000 lb., and ten passengers. While, therefore, the Secretary of State for Air is the ultimate authority controlling civil aviation, there are two bodies administering the control. The Air Ministry, through its Department of Civil Aviation, is concerned chiefly with policy and general regulation, while the Air Registration Board is concerned with airworthiness and technical supervision.

The second committee was appointed in 1936, under the chairmanship of Sir Henry Maybury, to

consider the development of civil aviation in the United Kingdom. It made a number of recommendations of which three were of particular significance. In the belief that internal air lines could be made to pay if competition were restricted, it recommended that various internal routes should be regulated and their services co-ordinated and that a licensing authority should be established to select the operating company or companies. It also recommended that radio facilities, a meteorological service and an air-traffic control organisation should be provided and maintained by the Government. The Air Transport Licensing Authority was subsequently established, but the scheme of air lines proposed has not been achieved. The third committee, under the chairmanship of Lord Cadman, was appointed in November, 1937. Its purpose was to inquire into the state of British civil aviation and to investigate charges of inefficiency in administration which had been made. Its report, made in February, 1938, is of the greatest importance in the history of British civil aviation. It pointed out the unfortunate effect on our prestige of having to employ foreign aircraft on British air lines. Aircraft operation and construction seemed to have been treated as separate questions and not as related parts of a single problem.

The committee visualised four elements in civil air transport which must be co-ordinated to assure successful development. These were, the machinery of Government, the aircraft operator, the aircraft constructor and the ground organisation. It urged the constant correlation of the policies of civil and military aviation, and besides the more obvious matters of finance and the prevention of clashing of interests, the co-ordination of research policies would need constant attention if duplication of effort was to be avoided. The committee made 35 recommendations, of which the first six dealt with the need for strengthening the administrative and technical civil aviation staffs of the Air Ministry. The most significant appointment made was that of a Director of Civil Research and Production and at the outbreak of war he was at work with a small technical staff. The next eleven recommendations dealt with the need for the expansion of British routes, the use of British aircraft on them and a further subsidy to British civil aviation. They also proposed close co-operation between the two British companies operating on routes outside Britain. These recommendations were accepted. The annual subsidy to civil aviation was increased from 1,500,000*l.* to 3,000,000*l.*, and steps were taken to amalgamate Imperial Airways and British Airways into a public utility company known as British Overseas Airways.

The last of the civil aviation committees, under the chairmanship of Mr. Harold Brown, was appointed in February, 1939, and reported in April of that year. Its purpose was to consider the proposed merger of Imperial Airways and British Airways, and how best to improve co-ordination between aircraft constructors, air-line operators and the Air Ministry. Its deliberations led to the conclusion that British civil aviation would stand a chance of occupying a leading position in world civil aviation only if large sums of public money—not more than a fraction of which would ever be recovered—were spent on it. Beyond suggesting that the civil-aircraft market might be encouraged by the Royal Air Force using civil aeroplanes as transports, the Committee made no proposals on how financial assistance should be given. The Brown committee suggested that the co-ordination they regarded as essential could best be provided by an advisory committee to be called the Civil Aviation Development Committee. It should include representatives of the Society of British Aircraft Constructors, the British Overseas Airways Corporation and the Air Registration Board. By the beginning of the war, the Government had made some progress in the appointment of this Development Committee, but no plans for financial assistance had been disclosed.

The outbreak of hostilities marked the end of a period in British civil aviation which might be called the committee period. The work of the various committees produced the Air Registration Board, the Directorate of Civil Research and Production of the Air Ministry, the Air Transport Licensing Authority and the British Overseas Airways Corporation. Of these, the Board continues, with a reduced staff to look after the technical needs of the war-withered body of civil aviation; the Directorate has ceased to exist; the Authority has also gone; but the Corporation, though beset with difficulties, is much alive. There is little doubt that had the war not intervened, many of the developments recommended in the various reports would have been directed by the Civil Aviation Development Committee. If, and when, that Committee is formed, its task, already gigantic, will be still more formidable, for in the few months since the war started, the position of British civil aviation has seriously worsened. A large proportion of its aircraft has been impressed for war purposes, its supplies of new aircraft are problematical and its officials are largely disbanded.

ENGINE AND PART WASHING MACHINES.

MESSRS. DAWSON BROTHERS, LIMITED, GOMERSAL, LEEDS.

(*For Description, see Opposite Page*).

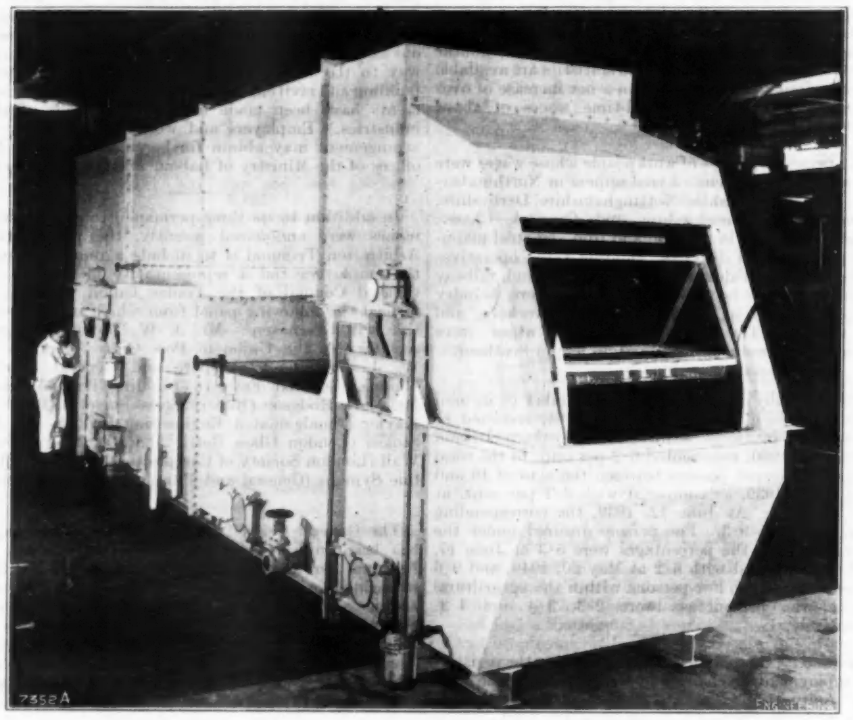


Fig. 1. Engine-Washing Machine.

Although the progress of civil aviation must inevitably be retarded, the necessity for planning so that this retardation can be neutralised and then converted into an acceleration is apparent. Knowing this, the Secretary of State for Air has announced his intention to set up a strong Civil Aviation Advisory Committee and to associate with it a small body of experts.

The Aim of British Civil Aviation.—In the past, British civil aviation has been too tentative and has suffered from a reluctance to define its aims. By British civil aviation we mean the civil aeronautical undertakings of the British Empire, not of the British Isles. For communications within the Empire there can be no other aim than that the routes shall be British and the aircraft operating on them shall be British. Of routes communicating with the rest of the world, half should be British, and on these the aircraft should be British. The Imperial routes are already extensive. Great Britain, Egypt, India, Australia and New Zealand are in direct communication. The trans-Atlantic route to Canada has been inaugurated. Egypt is joined with South Africa and West Africa. Canada is crossed from east to west. Australia is circumnavigated. The only obvious gaps are direct lines between Australasia and Canada and between Australasia and South Africa. Natural lines feed these main routes, and India, Australia, New Zealand, Africa and Canada all have their own systems. The total route mileage is impressive, being 89,077 in 1938, though the traffic is not large, the passenger miles per mile of route being 1,435. Corresponding figures are: United States, 71,199 route miles, 7,650 passenger miles; France, 40,833 route miles, 950 passenger miles; Germany, 30,490 route miles, 2,460 passenger miles; Russia, 58,036 route miles, 955 passenger miles. The figures for Germany and Russia are for the year 1937.

Prior to September, 1939, the main routes joining the British Empire to the rest of the world were: Great Britain-United States via Botwood; Great Britain-United States via Azores; Great Britain-Europe; United States-Hong Kong; United States-Australasia. The Empire had half a share of the first route, none of the second, operated her half of the third largely with foreign aircraft, and had no share in the rest. There were 21,100 miles of Empire main line and 63,500 miles of national line. Connecting the Empire with the rest of the world, there were 27,600 miles of air line. Taking these last routes first, only 6,900 miles were British operated, and on 5,500 miles of these the aircraft flying were 92 per cent. foreign.

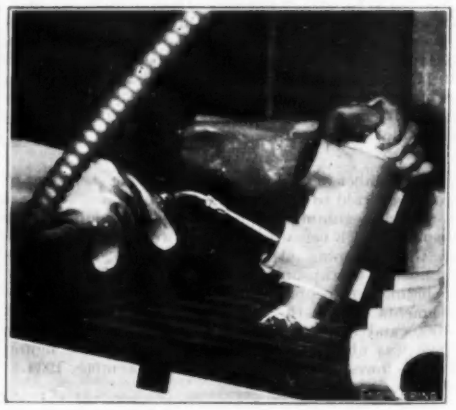


Fig. 2. Individual Spray Washing.

On 29,400 miles of the Empire's national lines, the aircraft operating were 68 per cent. foreign. So far, the Empire main routes are purely British; but four years ago most of the national lines and the British-operated Continental lines were. The danger grows. There are 84,600 miles of air line in the Empire. There are 27,600 miles connecting it with the rest of the world. All of the first and half of the second should be British controlled and operated by British aircraft. There are routes still to be opened up, perhaps 12,000 miles, in the Empire. We must see that these are all-British. There are countries with air routes, and countries needing air routes, with no national aircraft industries. We must study their conditions and compete with the other great exporters of civil aircraft for the markets. It is a legitimate aspiration of civil aviation to attract to itself all first-class mail and all the passengers in a hurry. The volume of this potential traffic is difficult to estimate, but for the routes mentioned such estimates should be the subject of special study. We should aim simultaneously for safety, speed, reliability and comfort. With these aims achieved, we shall have gained an enviable prestige.

The Means of Realisation.—If our aviation is to

ENGINE AND PART WASHING MACHINES.

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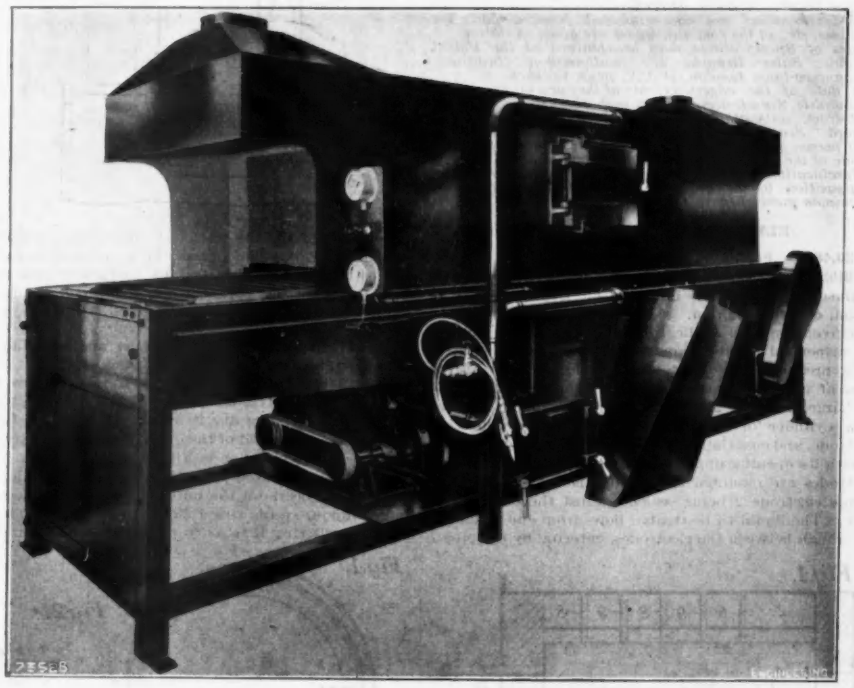


FIG. 3. WASHING MACHINE FOR MISCELLANEOUS PARTS.

advance towards the goal I have described, its many constituents must be fully co-ordinated. It will be of no use to extend our routes unless we are prepared to equip them with the latest devices for keeping aircraft on their courses and landing them safely. Highly organised routes will be halved in value unless the most modern aircraft fly along them. We shall not produce these modern aircraft without unremitting research, invention and development. None of these activities will be possible without a sane and generous financial scheme. The control of the constituents of civil aviation is the business of the Air Ministry. Its suitability for the task has often been questioned, mainly on the grounds that its primary concern is the Royal Air Force and that, in consequence, the needs of civil aviation are likely to be subordinated to those of the military branch. Those who would prefer civil aviation to be separated from the Air Ministry point to the mercantile marine, which in peace time is controlled by the Board of Trade and not by the Admiralty. Some would prefer to see civil aviation under the Board of Trade, others would prefer the Ministry of Transport; some would like to see it with a ministry of its own. This last arrangement has been adopted in the United States, where the control of civil aviation was, in August, 1938, removed from the Department of Commerce and placed in the hands of the Civil Aeronautics Authority. The Government's last published word on this question was in 1934, when they had "no intention of changing a basis of air organisation which has been so successful that it has since been adopted by foreign nations." This success has not been so marked as to prevent the Civil Aviation Advisory Committee, when it gets to work, weighing the advantages and disadvantages of other arrangements. The matter should receive careful and authoritative consideration.

One assumes that, in the future, the design of a civil air liner will generally be a direct response to a set of requirements laid down by the operator to meet the conditions of a particular route. This means that the operator must assess the traffic and the weather and other special conditions of the work, take account of any deficiencies in the type previously used and present the designer with a set of minimum requirements. There is one operational requirement which is rarely specified and which the designer would do well to bear in mind. If his aircraft proves, after extensive operation, to have a take-off well within the minimum requirements and has an ample margin of safety with one engine out of action, it is highly probable that, sooner or later, the operator will seek permission to increase the pay load. If the aircraft has been designed just to meet the minimum strength requirements, this will not be permissible without structural modification. The designer may be well advised, therefore, to arrange for a small reserve of strength. The operator finds himself in conflict occasionally with the airworthiness authorities; generally not on matters of principle. There is one case involving principle which will later on almost certainly have to be argued. It is this: the regulation minimum safety requirements are invariant with route. It can clearly be argued that, providing it is strong enough, an aeroplane should be allowed to carry more when flying over cool flat country between large sea-level aerodromes than when flying over mountains between high up aerodromes in the tropics. If it is argued, on the contrary, that the minimum safety requirements are so chosen as to make the aeroplane safe under both sets of conditions, then they are obviously uneconomic under the most usual conditions of operation. It is scarcely necessary to mention the certain call for greater speed and greater size. One stage less obvious is greater comfort. To get further ideas, however, about the future operational requirements, we shall have to consider particular routes, or classes of routes.

(To be continued.)

CHARTERED SURVEYORS' INSTITUTION.—Mr. Herbert Arthur Steward, who was recently elected President of the Chartered Surveyors' Institution, was honorary secretary of the Institution from 1930 to 1938, and is the first holder of that office to be elected to the Presidency.

SAFETY OF NEW WORKERS.—War-time conditions having introduced a number of new employees into engineering workshops and other factories, it is important that such raw material should be instructed on the risks to life and limb with which they are likely to be faced. The National Safety First Association (Incorporated), by its unremitting attention to the dangers of carelessness in the handling of machines, lifting appliances, and so forth, may be presumed to have educated regular workers to a considerable extent, and has now issued a booklet entitled *We don't want to lose you*, which is intended primarily for recruits to industry. Discarding lengthy formal instruction, which the pressure of to-day might leave unread, the new booklet consists of short, pithy, and serious advice driven home by a number of humorous drawings. The method seems to be promising, and to enable employers and others to judge for themselves, the Association will send a sample copy post paid for 3*d.*, on application to its office at 52, Grosvenor-gardens, London, S.W.1.

WASHING MACHINES FOR ENGINES AND PARTS.

THE overhall of internal-combustion engines that have been in service in which they are exposed to very adverse running conditions has, hitherto, been rendered a more lengthy process than need be by the necessity for removing accumulations of mud and dirt before they can be dismantled for reconditioning. Messrs. Dawson Brothers, Limited, Ventnor Ironworks, Gomersal, near Leeds, have, however, given the problem considerable attention, and some of their most recent machines for cleaning either complete engines or parts thereof are illustrated in Figs. 1, 2 and 3, on this and the opposite pages. The machine shown in Fig. 1, since it is designed for handling complete engines, is of considerable size, its overall dimensions being 33 ft. 6 in. long by 10 ft. 6 in. wide by 12 ft. 6 in. high. It consists essentially of an endless conveyor which passes successively through soaking, washing and drying chambers. The conveyor itself consists of a pair of heavy roller chains, of mild steel, to which are attached at intervals swinging baskets of the type seen to the right of the illustration. The conveyor runs very slowly and is driven by a 2-h.p. motor through a reduction-gear unit having a ratio of 14,400 to 1. The engine or parts to be cleaned are placed in one of the baskets at the opening seen and are traversed through the machine until they again reach the opening and are ready for removal.

As the carriers are traversed the engine or parts are first subjected to a soaking process in a special solution, heated to 180 deg. F., for a period of 30 minutes. On leaving the soaking chamber, from which they are automatically lifted by the disposition of the chain path, they are then subjected to a washing operation for 6 minutes. Washing is effected by numerous jets of clean water, also at a temperature of 180 deg. F., and at a pressure of 22 lb. per square inch. The jets are arranged all round the carrier so that no crevice in the engine or parts escapes their action. The carriers then pass out of the washing chamber and are subjected to jets of air for 2 minutes, a process which blows all the moisture from the cleaned work. The wash-water jets are derived from a centrifugal pump driven by a 15-h.p. motor and the delivery header is fitted with an air connection to the drying blast air supply, so that, if desired, the pressure of the jets can be increased above the 22 lb. per square inch normally used. The carriers are finally returned to the starting position. The machine is steam-heated and the temperatures are thermostatically controlled.

The second of the new machines has been designed for the efficient cleaning of carburettor parts for high-speed petrol engines. The machine is naturally a considerably smaller one than that employed for cleaning complete engines and the automatic cleaning is supplemented by hand operation. The carburettor parts are placed in wire baskets and passed into the washing chamber which contains a revolving table. This slowly turns the parts so that the numerous jets of strong washing solution, which jets are interlaced by being discharged from both sides, top and bottom of the chamber, strike the parts at continually altering angles and all intricate crevices, tapped holes, etc., are reached. The washing water in this chamber is constantly filtered. From this washing operation the parts pass into a second chamber provided with handholes and a glass panel, and illuminated by a lamp at the top. An operator, wearing rubber gloves, holds the parts in one hand and with the other directs a high-pressure wash-jet into each crevice or hole. The jet is supplied from the washing-solution pump and is controlled by a hand-grip operated nozzle, the operation being under observation through the glass panel. A view of this individual cleaning operation is given in Fig. 2, opposite.

In general, this machine is based on Messrs. Dawson's standard washing machine for small metal parts which require cleaning after machining from oil, grease, dirt, chips or swarf, or before machining for the removal of sand, etc. An example of this machine is illustrated in Fig. 3, above. It is fully automatic. The parts are normally carried through the machine in wire trays by means of a conveyor which is fitted with flight bars to carry parts too large to be placed in the trays. This conveyor can be recognised to the left of Fig. 3, its drive being indicated by the guard seen at the extreme right. The parts are traversed at a speed so determined that all portions are effectively cleaned. The period of washing is not left to the judgment of the operator, so that a constant output can be maintained. The machine can be fitted with either fixed wash pipes at the sides, top and bottom, or with rotating wash arms at the top and fixed wash pipes at the sides and bottom, the type of wash depending upon the nature of the work to be done. The centrifugal wash-water pump and motor are seen under the conveyor table. Similarly, if the work differs in type from time to time, variable-speed gear can be fitted to the conveyor, and if the nature of the material

renders sand or swarf exceptionally adherent, a vibrator attachment can be provided which, in conjunction with the streams of hot cleaning solution, removes these substances. The average dimensions of such a machine are 12 ft. in length by 4 ft. 6 in. wide by 6 ft. 9 in. high. The working opening is 18 in. square and the height of the conveyor is 3 ft. 6 in. from the ground. An 8-h.p. motor is required and heating is effected either by steam or gas, according to circumstances.

THE PORT OF WELLINGTON, NEW ZEALAND.

DESPITE severe import restrictions, the total cargo handled through Wellington last year improved on the record figures of 1938, according to the annual report of the Harbour Board for the year ended September 30, 1939. With 38 per cent. of the Dominion's total imports and 23 per cent. of the exports passing through Wellington, and with shipping arrivals maintained above 4 million net tons, the port has enjoyed a prosperous year. The Harbour Board have been endeavouring to convince the New Zealand Government of the suitability of the port as a flying-boat base in connection with the new Trans-Tasman air service, but, during the period covered by the report, no response had been received which was sufficiently encouraging to warrant expenditure on the construction of a base. Although the recent import restrictions led to the shelving of the port development scheme, however, the satisfactory financial position, represented by revenues totalling 636,919*l.*, was felt to justify relatively considerable expenditure on maintenance and new construction.

At Aotea Quay, good progress was made on the final 1,000 ft. of a new breastwork and on the superimposed store. One 5-ton and nine 30-cwt. electric overhead travelling cranes arrived from the United Kingdom to be erected by the Board's staff for use inside the store, while six 3-ton electric semi-portal cargo cranes for the berth alongside the store were expected to be delivered shortly. In the hydraulic pumping station, the rebuilding of one boiler for alternative firing with pulverised coal or oil fuel reduced the smoke nuisance resulting from variable loading. Jarrah wood being hard to obtain, decking and blocking on the Taranaki-street wharf were renewed with reinforced-concrete, at a saving in cost. Tractors are extensively used about the harbour premises, and 25 two-ton trailers were built in the Board's workshops, where 50 more are on order. The new dredger Kerimosana removed 49,515 tons of material from around the wharves, at an average cost of 20·65*d.* per ton; or, including depreciation and interest costs, 34·88*d.* per ton. During the year, the floating dock was used by 40 vessels, paying an average rate of 3·51*d.* per ton per day, and earned 5,657*l.*; expenses, however, exceeded twice that sum. Reconstructing and strengthening the central guide dolphin cost 2,503*l.*, and the dock has been completely overhauled and repainted, one mooring boom being experimentally treated with ship's anti-corrosive and anti-fouling paints; but no really satisfactory treatment for the floor of the dock has yet been found.

The Board are contributing 1,200*l.* towards the cost of the proposed Centennial Memorial on Petone Beach, which is to commemorate the landing, on September 21, 1839, of the preliminary expedition of the New Zealand Land Company. This company, organised in England by Edward Gibbon Wakefield (1796-1862), was responsible for the purchase of the site of Wellington from the Maoris, and for the start of ordered colonisation in New Zealand.

CATALOGUES.

Welding Electrodes.—We have received from Messrs. Lincoln Electric Company, Limited, Welwyn Garden City, Hertfordshire, a leaflet relating to the use of "Fleet-weld" electrodes.

Static Phase Converters.—Static phase converters, which can be arranged to act also as auto-transformers, are described in a leaflet (No. 11. M.) sent to us by Messrs. Westinghouse Brake and Signal Company, Limited, Pew Hill House, Chippenham, Wiltshire.

Electric Motors.—Messrs. The English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2, have sent us a pamphlet (No. W. 72) describing their Class LAS synchronous induction motors for power-factor correction, and a leaflet (No. W. 93) dealing with Class L W fan-cooled squirrel-cage motors.

Turret-Lathe Data.—Messrs. Gisholt Machine Company, Madison, Wisconsin, U.S.A., have made a practice for some years of publishing periodical data sheets, relating to the performance of their turret lathes. A series recently to hand deals with operations on small tools, steel castings for pulverisers, bronze bushes, and helical-gear blanks.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the names, etc., of the communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

520,481. Precipitation of Impurities from Liquids. J. Bibby and Sons, Limited, of Liverpool, Sturtevant Engineering Company, Limited, of London, and A. Ibison, of New Brighton. (6 *Figs.*) October 15, 1938.—The invention is an application of the method of separating suspended matter from liquids by means of electrostatic precipitation. The collecting electrode 1 is in the form of a continuously rotated horizontal drum. The discharge electrode 2 is in the form of a major segment of a cylinder of larger diameter than the collecting electrode, and co-axially surrounds the collecting electrode 1, with its opening uppermost, as shown in Fig. 2. The electrodes are mounted in a tank, the ends of the discharge electrode 2 being sealed against the ends of the tank. The liquid to be treated flows from end to end of the trough between the electrodes, entering by the pipe 7

Fig.1.

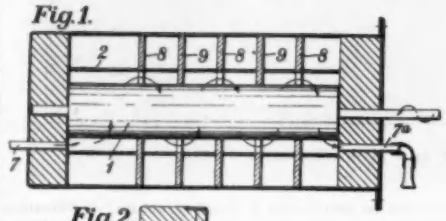
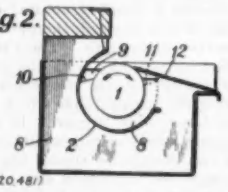


Fig.2.

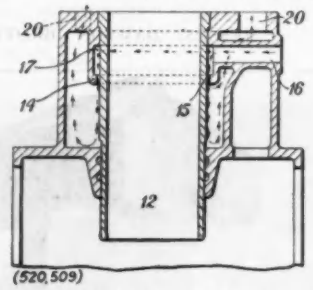


(520,481)

and leaving by the pipe 7*a*. This trough is divided into a number of treatment chambers by vertical partitions 8 and 9 at right angles to the axis of the electrodes. These partitions completely divide the tank so as to prevent any flow of liquid past them in the region outside the trough between the electrodes and they extend through slots in the electrode 2 as close to the collecting electrode 1 as possible. Portions of each partition close to the collecting electrode and within the trough extend above the level of the liquid on one side of the collecting electrode and below it on the other. The partitions 8 have portions of reduced height on one side at 10 and the partitions 9 on the other side at 11. Thus, these portions of reduced height form weirs over which the liquid flows from one treatment chamber to the next and, as these weirs are disposed alternately on opposite sides of the collecting electrode, the liquid in flowing from one end of the trough to the other passes backwards and forwards through the space between the electrodes. The matter deposited upon the collecting electrode 1 is continuously carried up out of the liquid by the rotating electrode and is removed by stationary scrapers 12. The collecting electrode 1 is earthed, and the electrode 2 is live. (*Accepted April* 25, 1940.)

INTERNAL-COMBUSTION ENGINES.

520,509. Cooling of Internal-Combustion Engines. R. A. Lister and Company, Limited, of Dursley, and H. R. Holton, of Stonehouse. (2 *Figs.*) November 3, 1938.—The invention aims at reducing the trouble found in some internal-combustion engines, and particularly compression-ignition engines, of the portion of the cylinder wall, towards the end where combustion is initiated, becoming heated to a greater extent than any other. The invention is particularly applicable to a multi-cylinder engine in which the cylinder barrels are in the form of wet liners fitted into a casting. In the multi-cylinder Diesel engine illustrated, a short distance from the top of the liner 12 is an inturned flange 14 on the casting which surrounds the liner with a relatively small annular clearance space 15. The cooling water is introduced along the passage 16 to the jacket space 17 round the liner on the side which is most highly heated, each cylinder having its own inlet 16. After circulating round this portion of the liner, the water passes through the restricted annular space 15 to circulate in the main



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jacket space round the rest of the liner, leaving through the passages 20. The size of the annular clearance 15 can be accurately controlled by machining this flange at the same setting as that at which the registers for the cylinder liner are machined. (*Accepted April* 25, 1940.)

520,351. Scraper Ring. D. Napier and Son, Limited, of London, and H. C. Tryon, of London. (8 *Figs.*) October 19, 1938.—The ring is designed to give uniform pressure round its circumference and to be unaffected by lack of concentricity due to wear. In a groove formed between the lower end of the cylinder A and an extension in a sleeve-valve engine is a solid ring D which is free to move to a limited extent in a radial direction. A split ring E bears on the outer surface of the sleeve B, and a sinuous spring ring F lies between the solid ring D and the split ring E so as to press the latter against the

Fig.1.

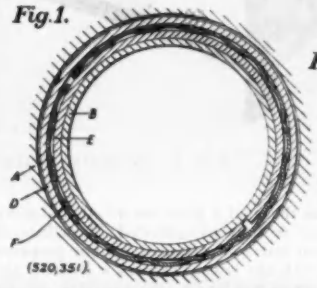
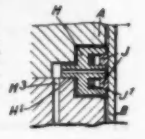


Fig.2.



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sleeve B. In the alternative construction shown in Fig. 2, the groove has a wide and a narrow part and in this groove is a solid ring H of E-section, with an annular projection H^1 fitting into the narrow part of the groove. In each of the two grooves which the ring H presents is a split ring J behind which is a sinuous spring ring J^1, similar to the ring F, to force the split ring into contact with the sleeve B. Passages for oil are drilled through the solid ring H and communicate with the narrow part of the groove from which runs a drain passage H^3. (*Accepted April* 22, 1940.)

MISCELLANEOUS.

520,513. Flywheel. The English Electric Company, Limited, of London, and E. H. H. Hassler, of Stafford. (5 *Figs.*) November 3, 1938.—The invention is a built-up flywheel in which provision is made for radial expansion of the rim. In Fig. 1, a number of steel discs 1 are welded or riveted together to form the boss and web of the wheel. A heavy ring 2 is fastened to each side of the web to form the rim of the wheel. The rim is forced to rotate with the web by tongues 3 or keys 3*a* fitting into radial grooves in the rim. The grooves in the rim are

Fig.1.

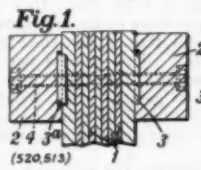
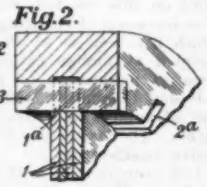


Fig.2.



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long enough to allow of the necessary relative radial movement. The rim 2 is also secured to the web by bolts 4, the bolt head being in a counter-bored recess in one rim piece and the nut in a corresponding counter-bored recess in the other rim piece. The holes in the rim pieces are slotted to allow the necessary radial movement and the holes in the web are counterbored from each end to give a similar clearance, the bolt being a fit in only a short central portion of the web. In the construction shown in Fig. 2, the rim is built up of a part surrounding the web and having a groove in which fits a locating spigot formed by machining the outer part of the web. Keys 3 pass through notches 1*a* and 2*a* and are retained by welding. In this construction, the securing bolts are dispensed with. (*Accepted April* 25, 1940.)